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APPLIED MECHANICS REVIEWS

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FREE STREAMLINE THEORY

DAVID GILBARG*

GRADUATE INSTITUTE FOR MATHEMATICS AND MECHANICS, INDIANA UNIVERSITY

THE problems of free streamline theory are concerned with flows of an ideal fluid bounded in part by constant pressure surfaces, usually of unspecified shape. These boundaries are called variously free streamlines, free surfaces, free boundaries, and sometimes streamlines of discontinuity. The principal applications of the free streamline concept are to jet, cavity, and wake phenomena, all of which exhibit such discontinuity surfaces to some degree. Various aspects of the subject have previously been reviewed in some detail (6, 9, 37, 49, 51) and comprehensive surveys are appearing at the present time (2, 18). The following exposition, for reasons of space, is concerned almost entirely with the exact theory. For approximate methods, many of which are useful in application, the reader is directed to the literature (e.g. (2, 7, 53)).

PHYSICAL BASIS OF THE THEORY

Helmholtz (26) introduced the streamline of discontinuity to avoid the unrealistically low pressures and high velocities occurring at sharp edges in the theory of ideal incompressible fluids. Prominent among the early applications of this concept was the model of the infinite wake, which postulates that in a flow past a bluff body, free streamlines detach from the surface and extend to infinity downstream enclosing a region at constant pressure. This description is of course in poor agreement with observation, as are also most of the quantitative results derived from it. However, in providing an elegant mathematical account of fluid resistance within the framework of classical hydrodynamics, it was a great stimulus to the further development of the theory. Recently a more refined but artificial model of the infinite wake which presupposes a base underpressure has given good agreement with drag measurements (10, 40).

In the last two decades it has become apparent that the assumptions of free streamline theory are better realized in cavitation phenomena. These are observed, for example, when a submerged body moves with a speed so high that the local pressures descend to the vapor pressure of the fluid, causing a vapor cavity to form behind the body. The relatively stable and well defined surfaces of discontinuity present here and in jet phenomena, but lacking in the wake, are essential in the success of the free streamline concept.

The basic nondimensional quantity of cavity flow is the *cavitation parameter* $\sigma = (p_\infty - p_c)/1/2\rho U^2$; here p_∞ and p_c are, respectively, the static and cavity pressures, ρ is the fluid density, and U the velocity of the stream relative to the body. In flows past a fixed obstacle, and in the assumed absence of gravity, viscosity, etc., the various flow quantities of interest, such as the forces and cavity dimensions, are functions of σ alone. The infinite wake—or cavity, as we shall call it—corresponds to $\sigma = 0$.

The basic problem of steady cavitational flow is to describe finite cavities with $\sigma > 0$. A difficulty arises here in that it is impossible in principle to satisfy the physical requirements (Brillouin's conditions (4)). These state that (1) the constant-speed free streamlines intersect neither themselves nor the given fixed boundary, and (2) the minimum pressure and maximum speed occur on the free surface. This difficulty has been circumvented in two different models of the finite cavity. One allows the free streamlines to turn back without intersecting, to form a jet which "passes through" the obstacle (8, 22). This *re-entrant jet* flow is the only one mathematically consistent with the given data, the maximum speed condition, and the assumption of steady irrotational motion. The jet is experimentally observed in both water entry and cavitation studies, and apparently is a very real feature of cavity mechanics. The simpler Riabouchinsky model of the finite cavity (38, 39) avoids the non-physical element of the two-sheeted flow plane by artificially closing the cavity at its rear, introducing the mirror image of the wetted obstacle as a streamline of the flow. It is a remarkable fact that despite the conceptual difference between these two models, they yield almost identical values of the drag and cavity dimensions (23, 24). The evident conclusion is that conditions at the rear of the cavity have but little effect on gross flow quantities. The greater simplicity of the Riabouchinsky model makes it a favorite in cavity calculations.

EXPLICIT SOLUTIONS AND NUMERICAL METHODS

Mathematically, the novel feature of the free boundary problem which distinguishes it from more traditional problems of potential theory is that an overdetermined boundary condition is assigned on an unknown curve (the free streamline), and this proves sufficient to specify the flow completely. The oldest, and to this day the most effective, technique for constructing free surface flows is the hodograph method. This method exploits the fact that for plane free surface flows of an incompressible fluid with *polygonal* fixed boundaries, the image of the physical plane in the velocity—or hodograph—plane is an essentially known region bounded by radial segments (corresponding to the fixed boundary) and circular arcs

*Professor of Mathematics, Stanford University after July 1, 1957

centered at the origin (the free boundary). Thus the determination of the flow is reduced to a classical problem of conformal mapping between known regions in the planes of the complex potential $f = \varphi + i\psi$ and the conjugate velocity $w = qe^{-i\theta} = df/dz$. The mappings can always be written in closed form but contain parameters whose effective determination is usually a difficult computational problem.

The literature of hydrodynamics contains a rich assortment of free surface flows calculated by the hodograph method (2, 6). Among the results that are useful in application are the motion and contraction coefficient in jet flow from various channel configurations, and the forces on an obstacle in cavity flow. Of particular interest for cavitation is the asymptotic formula for the drag coefficient—$C_D(\sigma) \sim C_D(0)(1 + \sigma)$—which holds quite accurately when $\sigma < 1$ (23, 24), and is in good agreement with observation for bodies having fixed separation points.

Another method of explicit solution, devised by Shiffman (45), avoids the hodograph mapping altogether but is applicable under precisely the same circumstances and yields formally equivalent results. This procedure is based on analytically continuing the flow across the free streamline in the physical plane and thereby effectively removing the unknown free streamline from discussion. If the fixed boundary is polygonal the flow region obtained after reflection is likewise polygonal. The entire flow can therefore be described in closed form by the Schwarz-Christoffel formula, without the intermediary of the hodograph mapping.

The preceding methods are the only ones known to provide explicit solutions of free surface problems for prescribed boundaries. Inverse and semi-inverse methods are presently the other means of constructing exact solutions, and while these are often of doubtful physical significance, they are an important step toward understanding the more complicated free boundary problems involving curved barriers, axial symmetry, gravity, etc.

The best known inverse method goes back to Levi-Civita (34). In his treatment of the infinite cavity behind curved obstacles he introduced as parameter plane the semicircle $|\zeta| \leq 1$, $\operatorname{Im} \zeta \geq 0$, under a correspondence taking the free streamlines into the diameter and the wetted obstacle into $|\zeta| = 1$. One observes that the function $\omega = \theta + i \log q$ is real on the real axis (if the cavity speed is unity) and hence can be defined by reflection in the full circle $|\zeta| \leq 1$. Conversely, any function $\omega(\zeta)$ which is analytic in the unit circle and real on the real axis determines with the known function $f(\zeta)$ an infinite cavity parametrized by $z(\zeta) = \int^{\zeta} e^{i\omega(\zeta)} f'(\zeta) d\zeta$. All cavity flows may be generated in this manner. Villat (49) derived from this representation of the flow a nonlinear integral equation for the function relating arc length on the fixed boundary with that on $|\zeta| = 1$. An approximate solution for a given obstacle determines an exact solution for the flow past an approximating body. These ideas can be extended to other cavity and jet models. Further important uses of the Levi-Civita representation and of Villat's integral equation appear in the general theory and numerical calculations.

Inverse and semi-inverse solutions have also been obtained for free surface flows in a gravity field (see refs. in (2), chap. 8), axially symmetric flows with given free boundary (12), oblique water entry of a wedge (13), and for a bubble flow involving surface tension (36). A general inverse method for constructing unsteady flows in a gravity field has been found by F. John (27). Another special flow describes accelerated motion of a finite cavity of constant shape (19, 28).

The lack of useful explicit solutions in all but the simplest problems has made it necessary to rely on numerical methods, and with the development of high-speed computing machines the numerical approach will probably become increasingly important. It should be pointed out that the labor and subtleties involved in accurate calculation of free surface flows are considerable. Many questions of accuracy are still unresolved, and rigorous proofs of convergence are lacking; for results in this direction see (52).

Plane cavity flows past curved boundaries have been calculated in a large number of cases (3, 5). The most effective method is based on trigonometric approximation to the solutions of (essentially) the Villat integral equation mentioned before, and reduction of the latter to a discrete system of equations.

Numerical methods have been especially valuable in problems of axially symmetric flow, for which useful explicit solutions are not yet known. The first important work of this character was the calculation by Trefftz (48) of the contraction coefficient of the jet issuing from a circular orifice in a plane wall. He obtained the value $C_c = 0.61$, a figure which is of particular interest because of its agreement with experiment and with the exact value $\pi/(\pi + 2) \approx 0.611$ obtained from the analogous two-dimensional problem. This has led to the conjecture that the plane and axially symmetric contraction coefficients are indeed the same. However, the accuracy of the calculation is in question because of the small number of interpolation points (six) on the free boundary. The method is based on a nonlinear integral equation easily derived by Green's theorem. The same idea has been used to calculate the surface impact forces in water entry of wedges and cones (50, 46) and the flow over a weir (30).

The relaxation method has been applied to several free surface problems (47), among them the jet efflux from a circular orifice, with the same result ($C_c = 0.61$) as obtained by Trefftz. Correct use of the finite difference procedure requires careful refinement of the mesh near separation where the streamline curvature is infinite. There is evidence that uncritical application of the method can yield relatively large errors in the position of the free boundary even though the computed velocity variations on the curve appear small.

A recent approach due to Garabedian (14) considers the axially symmetric stream function in a space of $\epsilon + 2$ dimensions and studies the solution in its dependence on ϵ, the case $\epsilon = 1$ of three-dimensional axially symmetric flow being the specific goal. In the problem of the vena contracta it is possible to deduce the ratio of jet to orifice diameter at $\epsilon = -1$, 0, and ∞, and by computation to obtain its derivative at $\epsilon = 0$. Interpolation among these values yields the contraction coefficient $C_c = 0.58$, in contrast with the generally accepted figure 0.61. Evidence of rapid convergence in the interpolation procedure lends strong support to the former result. The same method yields the drag coefficient 0.827 for the circular disk in the infinite cavity, as compared with the well-known value $2\pi/(4 + \pi) \approx 0.88$ in the corresponding two-dimensional problem. To treat the finite cavity Garabedian has developed a systematic iteration procedure based on a linearized form of the original boundary value problem (15). His results indicate that the $C_D(\sigma)$ curve increases in slope much more rapidly for axially symmetric than for plane flows.

GENERAL THEORY

The general theory has inspired a strong research effort among mathematicians, and in many ways this part of the subject is more highly developed than the theory of special solutions (e.g., in axially symmetric flow). Most results of the general theory concern flows satisfying the constant speed condition on the free boundary, and all of the following discussion deals with this class of flows.

Among the first problems introduced by curved barriers is that of selecting the separation point of the free streamlines. A natural criterion is provided by the result of Villat (49) which states that a free streamline detaches either with in-

finite curvature or with finite curvature equal to that of the fixed boundary. The latter type of detachment we shall call "smooth." Smooth separation from a closed body is obviously necessary for physical acceptability of a solution (in the sense of the Brillouin conditions), but is by no means sufficient—even for convex obstacles—as is easily seen by counterexamples. On the other hand, Leray (32) has shown that a convex arc with non-decreasing curvature on both sides of the stagnation point admits only physically acceptable solutions.

By means of the Levi-Civita representation it is easily proved that the plane infinite cavity is asymptotically parabolic in general, $y \sim Cx^{\frac{1}{2}}$, and that the drag is proportional to C^2. The axially symmetric case requires a much deeper analysis and yields the asymptotic shape $y \sim Cx^{\frac{1}{2}}/(\log x)^{\frac{1}{4}}$, with the drag now proportional to C^4 (35). Comparison with flows past ellipsoids indicates that the length-width ratio of the axially symmetric Riabouchinsky cavity is asymptotically $h/d \sim \left(\frac{1}{\sigma} \log \frac{1}{\sigma}\right)^{\frac{1}{2}}$ for small σ (14); in the plane case $h/d \sim 2/\sigma$.

Further illustrative geometric properties are the following which are stated for the infinite cavity; similar results apply to other cavity and jet models as well (41). In plane symmetric or axially symmetric flow, if a straight line does not cut the obstacle (in the upper half-plane) or the adjacent axis of symmetry, it can intersect the free boundary in at most a single point. This greatly limits the possibility of pathological behavior, and, in particular, implies that a monotonic obstacle can produce only monotonic free streamlines. If an obstacle T_1 lies above T_2 in the upper half-plane and T_1 and T_2 have the same endpoint A, then the relative positions of the corresponding free streamlines detaching from A are reversed. From this it follows that the drag on T_1 is less than on T_2. These and other qualitative results can be deduced from certain *comparison theorems* which describe changes in velocity on the boundary as the flow region varies (20, 31, 42). Since the comparison arguments rest on simple geometric considerations in the physical plane, many results generalize easily from the plane incompressible case to axially symmetric and subsonic flows (20, 21, 41, 42). The comparison method has thus far been applied only to problems of symmetric flow.

Most free surface flows can be characterized as extremal solutions of variational problems (16). Thus, among all bodies consisting of a fixed curve C, its image C^*, and variable curves joining the endpoints of C and C^*, the Riabouchinsky cavity having C and C^* as its fixed boundary and cavitation parameter σ achieves the minimum of $M - \sigma V$, where M is the *virtual mass* of the body and V its volume (or area). For the same flow the free streamline is characterized as the curve on which the maximum speed is a minimum. Aside from their intrinsic interest, variational methods can be useful in calculation of free surface flows (15).

From both the physical and mathematical point of view it is not at all evident what conditions are proper in general to determine a unique and meaningful solution of a free boundary problem. For example, the problem of finding a cavity with smooth detachment may admit more than one solution for an arbitrary symmetric convex obstacle (32) but only a single solution if the body has non-decreasing curvature. An extensive mathematical literature, to which many leading analysts have contributed, has by now settled in some generality the questions of existence and uniqueness of plane and axially symmetric cavity and jet flows past prescribed boundaries (see refs. in (2), (18)). Since these matters are primarily of mathematical interest we state most briefly the essence of the various methods.

The earliest general approach, the method of continuity (51), established the existence of plane flows past a given polygonal boundary by a process of continuous deformation starting from a known reference solution (such as the jet flow from a straight channel). Curved boundaries are then handled by polygonal approximation, and uniqueness is established by showing that the deformation process cannot bifurcate. The method of continuity was generalized in an important way by Leray (33) who obtained new results on infinite cavity flow by considering the solution of the Villat integral equation as a fixed point of a functional transformation. The fixed-point method was later applied to a variety of different problems, including the re-entrant jet (43), cusped and Riabouchinsky cavities (2), cavity flows in a channel (29), and subsonic cavities (1). The previously mentioned characterization of free surface flows by variational principles provides existence theorems when the corresponding variational problems are proved to have a solution (16, 17, 31). The most important contribution of this approach has been the first existence proof for axially symmetric cavitational flow. The theory of uniqueness, originally treated by the method of continuity, has in recent years been greatly simplified and extended by the comparison method (31, 44). Most results thus obtained hold also for axially symmetric and subsonic flow (20, 21). The principal unsolved problems of existence and uniqueness are those concerning asymmetric flows, for which partial results are available in the plane case (11, 33). The general theory for flows with other than the constant speed condition on the free boundary is largely unexplored, although gravity flows are treated in (16) and in the theory of surface waves.

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"Letters to the Editor" and "Book Received for Review" appear after the reviews

Theoretical and Experimental Methods

(See also Revs. 1330, 1331, 1332, 1334, 1336, 1339, 1379, 1416, 1460, 1494, 1495, 1524, 1526)

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Author shows that the most general relation between symmetric tensors of second order is a polynomial of second degree, and expresses in a general manner the coefficients in this polynomial in terms of the three tensor invariants. He mentions the light shed by these results on certain experiments such as the Weissenberg effect.

The same results have been obtained previously by the author making use of geometrical considerations.

W. Freiberger, USA

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The object of this note is the determination of conditions for asymptotic stability in the large of the origin for a system

$$\dot{x} = f_1(x,y), \quad \dot{y} = f_2(x,y), \quad \dot{z} = f_3(x,y,z)$$

under the following conditions: (a) The f_i satisfy the usual continuity and unicity assumptions for all x,y,z; (b) $f_i = 0$, $i = 1,2$, determines a curve s_i in the x,y plane which divides the latter into two parts, in one of which $f_i > 0$, and in the other $f_i < 0$; (c) the curves $s_i = 0$ intersect at the origin and nowhere else, and $f(0,0,z) = 0$ only if $z = 0$; (d) there is no closed solution of $x\,dy - y\,dx = 0$; (e) $f_3 = 0$ defines in $x^2 + y^2 \leqslant \rho^2$ a continuous function $z = \varphi(x,y)$; (f) $(\varphi - z)/f_3 > 0$ for $z \neq \varphi$; (g) the origin is asymptotically stable.

Under these conditions author proves several rather complicated theorems the simplest of which is: Suppose that the domain A of asymptotic stability is not the whole space. Let also $f_1 = 0$, $f_2 = 0$ define single-valued functions $y_1(x)$ for $x \geqslant c_1$ and $y_2(x)$ for $x \leqslant c_1$ and similar functions $x_i(y)$; then the boundary of A consists of at most four cylindrical surfaces. S. Lefschetz, Mexico

1311. Simanov, S. N., On the problems of finding the characteristic exponents of systems of linear differential equations with periodic coefficients (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **109**, 6, 1102–1105, 1956.

Consider the n-vector system

$$\dot{x} = [A + \mu F(t,\mu)]x \qquad [1]$$

where A is a constant matrix and F has period 2π in t and is analytic in μ (real) in some interval $|\mu| < \mu^*$. Let λ_1 be a characteristic root of A. The analytic nature of the characteristic exponent of [1] corresponding to λ_1 a simple root has been discussed in the following papers: Artemie, *Izv. Akad. Nauk SSSR, math. Ser.* **8**, no. 2, 1944; Shimanov, *Prikl. Mat. Mekh.* **16**, no. 2, 1952. The present note takes up the case where λ_1 is multiple or even where two λ's differ by a multiple of i. The nature of the fractionary powers of λ_1 in the expansions of the characteristic exponents is fully determined. S. Lefschetz, Mexico

1312. Wiebelitz, R., Connection between a system of linear differential equations and Volterra integral equation with explicit kernel (in German), *Arch. Math.* **7**, 3, 184–196, 1956.

Book—1313. Transactions of the symposium on partial differential equations, Univ. Calif., June 20–July 1, 1955, New York, Interscience Publishers, Inc.; London, Interscience Publishers Ltd., 1956, vi + 334 pp. $6.50.

Twenty-eight papers presented at Berkeley Symposium on partial differential equations in summer of 1955 were published in August 1956 issue of Communications on Pure and Applied Mathematics **9**, pages 299–623. These papers are reprinted to form the book under review from essentially the same plates (with new page numbers). Some of individual papers will doubtless be reviewed in AMR.

Papers represent original research of respective authors and range from use of digital computers to discussion of existence theorems with sidelines including calculus of variations and specialties such as the validity of Huygen's principle in helping to characterize solutions of Cauchy-type problems.

Results are mathematical in nature; applications to specific problems are given in many papers. Some papers give summaries of historical background; many papers suggest unsolved problems.

R. E. Greenwood, USA

1314. Goodman, T. R., and Lance, G. N., The numerical integration of two-point boundary value problems, *Math. Tables Aids Comput.* **10**, 54, 82–86, Apr. 1956.

Authors consider two-point boundary-value problems and develop two methods for converting the linear case into initial value problems. One method uses complementary functions, and the other uses the adjoint system of equations. Authors assert that the method of complementary functions is good for a single problem, but if solutions are required for several forcing functions the other method is better. For nonlinear equations, they develop an iterative procedure.

H. D. Huskey, USA

1315. Healy, M., and Westmacott, M., Missing values in experiments analysed on automatic computers, *Appl. Statistics* **5**, 3, 203–206, Nov. 1956.

An excellent method is suggested for computing missing values from block experiments with the use of an automatic computer. The method proposed is an improvement on that of minimizing residual sum of squares in accordance with standard techniques. The proposed technique involves the checking of residual areas for each value. This method is also applicable to the IBM-650 digital computer.

J. H. Davidson, USA

1316. Comstock, G. E., 500,000,000-bit random-access memory, *Instrum. and Automat.* **29**, 11, 2208–2211, Nov. 1956.

1317. Weiss, G. H., A note on the coincidence of some random functions, *Quart. appl. Math.* **14**, 1, 103–107, Apr. 1956.

At least two, in general n, machines of the same statistical behavior are set into operation at time $t = 0$. Whenever a machine breaks down it is replaced by a new one. The operating time l of any machine and the replacement time m are given by probability densities $\alpha(l)$ and $\beta(m)$, respectively. The author asks for the expected fraction of a time interval $(0,T)$, during which all machines are being simultaneously replaced. The answer is related to the probability density $\eta(t)$ of a single machine to operate at time t. The calculation of η involves some auxiliary densities A, λ, ϕ, ω which, together with η, are related by $A(t) = \int_t^\infty \alpha(l)dl$; $\lambda(t) = \int_0^t \beta(r)A(t-r)dr$; $\Phi(t) = \int_0^t \beta(r)\cdot\alpha(t-r)dr\omega(t) = \phi(t) + \int_0^t \omega(r)\phi(t-r)\cdot dr$ and $\eta(t) = \lambda(t) + \int_0^t \omega(r)\lambda(t-r)dr$. These can be solved for η, preferably by means of the Laplace transformation. The author gives an example; he also studies conditions on α, β in order to insure the existence of a limit $\eta(t) \longrightarrow C$ when $t \longrightarrow \infty$.

H. F. Buckner, USA

1318. Kestin, J., and Persen, L. N., On the error function of a complex argument, *ZAMP* **7**, 1, 33–40, 1956.

The error function of a complex argument and allied functions occur in many problems of physics or engineering. They occur, for example, in the theory of heat conduction, particularly when nonsteady heat conduction through stratified media is concerned, as well as in problems of electrochemical diffusion. Among the additional fields of application, electrical transients, electromagnetic theory, and rocket ballistics may be mentioned. The application of the error function to problems in statistics and of the allied Fresnel integrals to classical diffraction problems is also very well known.

In spite of their great usefulness, the tabulation of the error and related functions of a complex argument has not progressed very far because of their complexity as well as because of the large amount of numerical work involved. Rosser made a comprehensive study of the methods of integrating the functions.

From authors' summary

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 1349, 1352, 1390, 1397, 1419, 1495, 1557, 1568)

Book—1319. Biezeno, C. B., and Grammel, R., Engineering dynamics, Vol. II. Elastic problems of single machine elements, London, Blackie & Son, Ltd., 1956, x + 527 pp. 90s.

Volume contains the translation of the second portion of the second edition of "Technische Dynamik" [AMR **7**, Rev. 694]. The translation of the third and forth portions [AMR **8**, Revs. 1278 and 1279] and the first portion [AMR **8**, Rev. 2645] appeared earlier. The translation into English is now complete.

This second volume contains four parts, Beam and shaft, Spring and ring, Plate and shell, and Problems of elastic instability. It serves as a stepping stone from the fundamentals of elastomechanics of the first volume to the more complicated problems of turbines and combustion engines of the last two volumes.

Engineering students of the English speaking world can feel grateful to have now the use of this famous work.

F. I. Niordson, Sweden

1320. Seliger, V. H., Speed-torque analysis for rotating mechanical systems, *Prod. Engng.* **27**, 13, 184–186, Dec. 1956.

Author presents a systematic method for deriving and solving equations for speed and torque in an "ideal" rotating system. A succeeding article will extend the method to include the effects of inertia, compliance, and friction.

From author's summary

1321. Kotov, V. F., A general expression for the fundamentals of dynamics (in Russian), *Sbornik st. Vses. zaoch. polytech. in-ta* no. 8, 98–107, 1954; Rev. no. 655, *Ref. Zh. Mekh.* 1956.

Systems are examined, formed of solid bodies with internal freedom of motion of the particles. Applying the "freezing" method [F. R. Gantmacher, L. I. Levin, *Prikl. Mat. Mekh.* **11**, no. 3, 1947], the known expressions are obtained for the changes in quantity of motion, kinetic motion and kinetic energy, for both absolute and relative motion.

An example is adduced of the derivation of the motion of a body linked with a gyroscope, the relative kinetic moment of the gyroscope being assumed constant.

V. S. Novoselov, USSR

Courtesy of Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

1322. Templin, R. J., and Callan, M. M., Generalized trajectory curves for bodies moving in air, *Nat. aero. Establ. Canad.* (LR-159), N 13, 5 pp. + 4 figs. + appendix, Mar. 1956.

A chart has been constructed which enables rapid development, using a step method, of trajectory curves having any initial values of the ratio initial velocity to terminal velocity, and the angle of the trajectory to the horizontal.

The ratio V/V_t is used as a variable to extend the usefulness of any one trajectory which is developed.

From authors' summary

1323. Shchigolev, B. M., Intermediate orbits in the 3-body problem (survey) (in Russian), *Trudi Astronom. Inst.* no. 24, 59–92, 1954; Rev. no. 18, *Ref. Zh. Mekh.* 1956.

An examination is made of the methods suggested by various authors of constructing intermediate orbits in the 3-body problem, and an attempt is made to classify them, on the basis of concepts of two fundamental requirements which are made for intermediate orbits. Author differentiates between two classes of intermediate orbits. The first class refers to intermediate orbits which are obtained by the formal simplification of the power function of the problem. The second class refers to intermediate orbits the construction of which is based on empirical data, either entirely or in conjunction with theoretical factors. From the first class, Kepler's intermediate orbit, the intermediate orbits of d'Alembert, Poisson, Goolden, Zhdanov, Hill's intermediate orbit, the intermediate orbits obtained by application of N. D. Moiseev's theory, and a number of others are examined. The second class refers to the intermediate orbits of Clereau and Laplace and also orbits obtained by using N. D. Moiseev's interpolated average theory.

Courtesy of Referativnyi Zhurnal G. N. Duboshin, USSR
Translation, courtesy Ministry of Supply, England

1324. Halberg, M. N., Calculating the size of flywheel required for a synchronous motor driven reciprocating compressor, ASME Fall Meet., Denver, Colo., Sept. 1956. Pap. 56-F-18, 12 pp. + 12 tables + 5 figs.

1325. Wunderlich, W., Approximate straight guiding with help of symmetrical linkages (in German), *ZAMM* **36,** 3/4, 103–110, Mar./Apr. 1956.

An elementary algebraic theory, permitting an easy computation and giving a clear insight into the various possibilities, is presented for the approximate straight-line motion, developed by Chebychev by means of axially symmetric three-bar curves with a triple vertex tangent.

From author's summary by A. S. Hall, USA

1326. Gulans, A. Ya., The problem of determining the mechanical efficiency of toothed wheels (in Russian), *Zap. Voronezhsk. S-Kh. Inst.* **25,** 1, 130–134, 1954; Rev. no. 63, *Ref. Zh. Mekh.* 1956.

A formula is deduced for determining the efficiency of toothed gear wheels. In the relationship is considered the coefficient of friction, the value of the load, sliding velocity of the teeth, and viscosity of the oil. Coefficients which make up the formula require experimental determination. V. A. Zinov'ev, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1327. Manzheron, D. I., Graphic and analytic methods used in the kinematics of material systems (in Russian), *Dokladi Akad. Nauk SSSR (N. S.)* **102,** 5, 897–898, 1955.

1328. Rothbart, H. A., Cam pressure angles, *Prod. Engng.* **28,** 1, 193–195, Jan. 1957.

Paper discusses selection of maximum pressure angle based on distribution of forces in the cam follower. Four types of cam followers are analyzed: overhead, system with a secondary follower, flat-faced follower, oscillating roller.

From author's summary

1329. Brooks, J. E., Calculation of feel cam contour, *Aero. Engng. Rev.* **15,** 9, 37–38, Sept. 1956.

Author presents an analytical method for calculation of the contour of a spring-loaded cam to create artificial "feel" for a fully powered aircraft control system. Upon selection of certain basic geometrical parameters, points of a cam contour that will produce a desired cam-moment versus cam-angle function can be directly calculated. The presentation is all too brief, many symbols being left completely undefined and making a fairly simple analysis difficult to follow. The simple and straightforward analysis is, in addition, made unnecessarily complex by the use of vector notation where the application of elementary geometry and trigonometry would suffice. A. J. Chapman, USA

Servomechanisms, Governors, Gyroscopics

(See also Revs. 1329, 1337, 1459, 1558, 1559)

1330. Donegan, J. J., and Huss, G. R., Incomplete time response to a unit impulse and its application to lightly damped linear systems, *NACA TN* 3897, 17 pp., Dec. 1956.

For the practical determination of the frequency response of an aircraft, the difficulty is that the recorded time response to a given input is only available up to a finite time λ. The Fourier transform of the output is then taken as an integral from 0 to λ instead of from 0 to ∞. This induces errors in the frequency response, which may cause the false impression of structural modes of high frequency (period equal to $2\pi/\lambda$). Authors show that if this incorrect frequency response is used for determining the time response to a unit impulse, the result will be reliable up to the time 0.9λ. The same satisfactory result holds if, by means of Duhamel's integral, the response to an arbitrary input is calculated. A. I. van de Vooren, Holland

1331. Aizerman, M. A., and Gantmakher, F. R., On the determination of periodic regimes in a nonlinear dynamic system with piece-wise linear characteristic (in Russian), *Prikl. Mat. Mekh.* **20,** 5, 639–654, 1956.

The system under discussion is

$$\dot{x} = \alpha x + \rho f(x_1)$$

where x and α are n-vectors, α is a constant square matrix and f is a scalar function. It is assumed that f is piecewise linear (several pieces) and the calculations are carried out in the obvious and only possible manner. There are 12 references to automatic regulation. S. Lefschetz, Mexico

1332. Balchen, J. G., A graphical method for determination of closed loop frequency response curves for feedback control systems containing nonlinear elements, *Tekn. Skr.* 15, 21 pp., 1956.

Paper is convenient summary of "describing function" techniques for solving nonlinear feedback control problems. This approach is of practical value in design; the limitations imposed by its approximate nature are treated in this paper. Some concepts introduced are new, others clarify previously known techniques. In each case, author evaluates validity of approximation inherent in method, studying significance of neglected harmonics. Included are such effects as jump-resonance, various types of hysteresis, and some frequency-dependent nonlinear effects. Accent is on simplifying graphical techniques.

R. Kochenburger, USA

1333. Egorov, K. V., Stability of automatic regulation systems (in Russian), Ucheb. Posoble Dlya Studentov Spetsialnosti *Avtomat. Telemekhanika* 79 pp., 1954; Rev. no. 52, *Ref. Zh. Mekh.* 1956.

Courtesy of Referativnyi Zhurnal

1334. Engel, F. V. A., On the true non-dimensional groups of dynamic similarity (in German), *Regelungstech.* **4,** 8, 184–190, 1956.

1335. Khalimanovich, M. P., A generalization of the concept of the coefficient of gyroscopic stability (in Russian), *Uchen. Zap. Belorus, Univ.* no. 19, 93–98, 1954; Rev. no. 22, *Ref. Zh. Mekh.* 1956.

The case is examined of the motion of a not completely symmetrical gyroscope in which the coefficient of dynamic asymmetry is fairly small. An approximate equation is developed for the mutation angle, and the qualitative picture of the gyroscope's motion is stated. A concept of the coefficient of gyroscopic stability for the asymmetrical gyroscope is introduced, similar to that for the symmetrical gyroscope. I. A. Balaeva, USSR

Courtesy of Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

Vibrations, Balancing

(See also Revs. 1331, 1419, 1454, 1638, 1639)

Book—1336. Bishop, R. E. D., and Johnson, D. C., Vibration analysis tables, New York, Cambridge University Press, 1957, viii + 59 pp. $2.

Booklet is a separate publication of vibration tables to be included in a forthcoming book by the same authors. Tables of admittances (called receptances by the present authors) for torsional systems, strings, shafts, and longitudinal and flexural vibrations of beams are provided in a useful and convenient fashion. A very useful table of beam characteristic functions [AMR **3**, Rev. 832] is also included. H. N. Abramson, USA

1337. Troickii, V. A., On the problem of self-vibrations in systems of automatic regulation with two servomotors of constant velocity (in Russian), *Prikl. Mat. Mekh.* **20**, 5, 627–638, 1956.

The basic equation is

$$\dot{x} = bx + b_1 f_1(\sigma_1) + b_2 f_2(\sigma_2),\ \sigma_i = j_i x \qquad [1]$$

Here x, b_i are n-(column)-vectors, the j_i are constant row vectors, b is a constant $n \times n$ matrix and the f_i are scalar functions, the characteristics of the two servoes. These are assumed of "on-off" type, so that the f_i have each just one jump and are constant otherwise. Assuming coordinates such that b is in normal form, the calculations are carried out in detail in the obvious way. Same treatment for servos with constant speed. The equations are then

$$x = bx + n_1 \xi_1 + n_2 \xi_2$$
$$\xi_i = f_i(\sigma_i),\ \sigma_i = j_i x + r_{i1} \xi_1 + r_{i2} \xi_2$$

S. Lefschetz, Mexico

1338. Hearmon, R. F. S., The frequency of vibration and the elastic stability of a fixed-free strip, *Brit. J. appl. Phys.* **7**, 11, 405–407, Nov. 1956.

Tests are reported which show the practicability of obtaining experimentally the buckling load of a column as the load of which the lowest natural frequency becomes zero.

B. A. Boley, USA

1339. Nowacki, W., Free vibrations and buckling of a rectangular plate with discontinuous boundary conditions, *Bull. Acad. Polonaise Sci.* **3**, 4, 159–173, 1955.

The method, which is basically a numerical evaluation of Green's function (which involves the eigenvalues in this case), assumes an infinite trigonometric series for the "unit moment" at the boundary having "discontinuous conditions." The integral equation for determining Green's function involves the eigenvalues (buckling load and natural frequencies) and the coefficients of the trigonometric series. The discontinuous boundary is divided into discrete segments and the line integral approximated by a summation along this boundary. This results in a system of equations each term of which, however, is an infinite series (truncated for calculation purposes) of transcendental terms involving the desired eigenvalues. The eigenvalues are determined by setting the determinant of this system of equations equal to zero.

Author has three example problems, in one of which the nonhomogeneous portion of the boundary was divided into three equal segments (which results in a system of three equations). He then evaluated the eigenvalues by a trial-and-error method. Unfortunately he did not state how many terms were taken of the infinite trigonometric series nor did he vary the number of segments into which the boundary was divided. Thus it is impossible to evaluate the convergence of the numerical solution as a function of either the number of terms into which the boundary is divided or the number of terms retained in the trigonometric series. It is also unfortunate that, due to the complexity of the problem, no other solutions seem to exist with which to compare author's solutions.

Author is to be complimented on a very clear and concise explanation of his method. It appears, however, that the method is not easily applicable to the use of digital computers, and hand calculations would seem to be extremely laborious.

A. L. Ross, USA

1340. Penzien, J., Wind induced vibration of cylindrical structures, *Proc. Amer. Soc. civ. Engrs.* **83**, EM 1 (*J. Engng. Mech. Div.*), Pap. 1141, 17 pp., Jan. 1957.

Paper presents the results of a wind-tunnel investigation to determine the dynamic behavior of cylindrical sections under the action of wind at high Reynolds numbers. These results show that wind-induced vibration normal to the direction of wind is "self-excited" rather than "forced." Two critical wind velocities were observed. The lower critical velocity appears to be associated with the von Karman vortex street. However, the basic aerodynamic phenomenon associated with the higher and more severe critical velocity is not presently understood.

From author's summary by H. N. Abramson, USA

1341. Leclerc, J., Modification of the proper shape of a structure by addition of small masses (in French), *Rech. aéro.* no. 50, 45–50, 1956.

Paper gives account of a very important technique in vibration analysis. An expression is obtained for amplitude at any point in a structure performing a normal mode in terms of rate of change of natural frequency with small concentrated mass added at point under consideration. Method is equivalent to finding generalized mass of structure in any normal mode. Technique can form basis of important experimental approach.

Reviewer believes that analysis given can be simplified without loss of generality. K. H. Griffin, England

1342. Korchinsky, I. L., Oscillations of high buildings (in Russian), *Nauk soobsbcb. Tsentr. n-i. Inst. prom. sooruzhenii* no. 11, 1–43, 1953; Rev. no. 498, *Ref. Zh. Mekh.* 1956.

Results are given of the theoretical and experimental investigation of the free oscillations of 3 high buildings in Moscow. The maximum amplitudes of the free horizontal oscillations of these high buildings at the level of their upper storys during the period of observation did not exceed 0.15 to 0.25 mm. The frequencies of the fundamental free oscillations of all the buildings investigated were approximately identical in both directions of their main axes in plan view, and amounted to 0.60, 0.70, and 0.84 cps. The shear deformation is predominant.

The actual lateral rigidities of these high buildings with small wind loads exceeded the calculated rigidities of their frameworks by approximately 5 to 20 times, which indicates the considerable participation of the filling in of the framework in resistance to the displacing forces.

An approximate formula is given for estimating the frequency of the free oscillations. A. G. Nazarov, USSR
Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1343. Cox, H. L., The riding qualities of wheeled vehicles, Instn. mech. Engrs. Auto. Div., Prepr., 12 pp.

A wheeled vehicle traversing an irregular road surface is subjected to forced vibration. This vibration is analyzed into heaving, pitching, and rolling modes, and means are described to compute or simulate the response of the vehicle both to continuous excitation at definite frequencies, and to isolated obstacles affecting one wheel at a time.

It is shown that a simple model, comprising only rigid masses, linear springs, and velocity damping, suffices to represent the riding quality of the vehicle, and a procedure by which the model may be matched to the vehicle as closely as possible is described.

The theory is illustrated by computation of the impact loads imposed on the wheels of a six-wheeled lorry when surmounting artificial obstacles, allowance being made for the effects both of the wheels leaving the road, and of interaction between the four wheels in the rear truck. Good agreement with experimental records of wheel load is shown, and it is suggested that similar computation or simulation applied to passenger-carrying vehicles would prove of value in the improvement of riding quality.
From author's summary

1344. Abramson, H. N., and Wilson, B. W., A further analysis of the longitudinal response of moored vessels to sea oscillations, Proc. second Midwestern Conf. solid Mech. Purdue Univ., Sept. 1955, 236–251.

Paper is useful extension of an earlier work of the second author, AMR **5**, Rev. 2533. The effect of seiches on moored vessels is studied and analytical solutions are presented for the longitudinal response of ships in harbor basins. The underlying second order, ordinary, strongly nonlinear (in the restoring term) differential equation with a single-frequency harmonic input is solved by an averaging process derivable from variational principles. (For a systematic presentation see K. Klotter "Nonlinear vibration problems treated by the averaging method of W. Ritz"; AMR **6**, Rev. 2996.)

A clear and quantitative discussion of the response to increasing and decreasing seiche amplitudes is given, including phase relations, using a quasi-steady approximation. Small amplitude out-of-phase and large amplitude in-phase motions are the two stable modes of oscillation. Discussion of the important questions of sub- and superharmonic as well as coupled motions is promised in future papers.

It is hoped that the profession will have the benefit of further investigations by the authors at an early date. Paper is strongly recommended for its clear, concise style and useful results. (Very recent reference of some practical interest, not mentioned in the paper, is W. Munch, "Modern practice in mooring of ships," *Soc. nav. Arch. mar. Engrs. Bull.* **XI**, 3, 1–17, 1956).
V. G. Szebehely, USA

1345. Scotto Lavina, G., On the calculation of bending-torsional vibrations of a crankshaft–airscrew system (in Italian), *Aerotecnica* **36**, 4, 278–290, Aug. 1956.

Author gives two alternative methods for solution of title problem, taking full account of skew bending vibrations of airscrew blades. In first method system is decomposed in a well-known way with a cut at hypothetical nodal point of shaft, close to screw hub in one torsional system of m degrees of freedom and one bending system. Screw blade mass is substituted by n mass points, lumped to beam, leading to $2n$ degrees of freedom for bending system. Author has shown in previous note how escalator method may be applied to bending system [*R. C. Ist. Lombardo Sci.* **89**, 1956]. In second method, a system of $2n + m + 1$ equations is attacked directly with iterative method. Numerical example with twelve degrees of freedom is treated and favorably compared with solution of J. Morris ["The escalator method in engineering vibration problems," London 1947]. F. K. G. Odqvist, Sweden

1346. Kumai, T., Coupled torsional-horizontal bending vibrations in ships, *European Shipbldg.* **5**, 4, 95–98, 1956.

Classical, analytical treatment is presented of coupled torsional-bending vibration of a ship-like beam of variable cross section, with straight axes of the center of gravity and of the torsion center. Further, author assumes that the mass, the polar mass moment of inertia, and both the shear and torsional rigidities increase linearly toward the midship section. The distance between coupled frequencies is small even when the distance between the axes of the center of gravity and of the torsion center is considerable. It is estimated that the two peaks of coupled natural frequencies are separated by a distance equal to 10% of the mean value of the two peaks. E. G. Fischer, USA

1347. Mattes, N. V., Theoretical basis for calculating the damping of local vibration in the bottom of a ship's engine room (in Russian), *Trudi Gorkovsk. Politekh. Inst.* **9**, 1, 55–62, 1954; Rev. no. 39, *Ref. Zh. Mekh.* 1956.

The problem is investigated of free and induced oscillations of a ship's bottom covering when an imperfectly balanced engine is installed with a damping arrangement. General calculation formulas are deduced which make it possible to estimate the damping effect, depending on various factors which enter into the problem. Approximation methods of calculating the vibration of the bottom covering are suggested. Yu. A. Shimanskii, USSR
Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1348. Yeates, J. E., Jr., Flight measurements of the vibrations encountered by a tandem helicopter and a method for measuring the coupled response in flight, *NACA TN* 3852, 28 pp., Dec. 1956.

In this investigation a typical tandem helicopter with three-blade rotors was used. This helicopter was known to have a high vibration level under certain conditions. Both ground and flight tests were conducted, the response of the helicopter structure to mechanical shaking (forced vibration) being measured at various points. In addition, natural vibrations were recorded for a range of speeds and powers.

Results are given which show the coupled response in flight with wooden and with metal blades having different mass and frequency characteristics, the coupling occurring between fuselage bending and blade bending. The presence of this coupling is shown by the fact that flight response curves show two peaks, whereas the ground response curves show only one. The modal frequencies are in fair agreement with those predicted by theory [*NACA TN* 3849].

The limitations of these tests are discussed, and a modified flight test technique is suggested, in which the forced excitation would be provided by a hydraulically actuated mass.
A. W. Babister, Scotland

1349. Grubin, C., On the theory of the acceleration damper, *J. appl. Mech.* **23**, 3, 373–378, Sept. 1956.

The acceleration damper is a type of nonlinear dynamic absorber; a ball, say, bounding between the ends of a closed cylinder has a damping effect upon the vibration of the system to which it is attached. Author has extended the analysis of this device, providing equations for analysis and design. Though two worked-out numerical examples are included, these are insufficient to permit evaluation of the device relative to older types of absorbers. R. A. Burton, USA

1350. Himelblau, H., Jr., Analytical methods for designing—Dynamic vibration absorbers, *Mach. Design* **28**, 19, 134–140, Sept. 1956.

A dynamic vibration absorber is described for reducing the forces transmitted to the foundation by a machine subjected to a harmonically varying force or moment. The absorber is essentially a mass mounted elastically on the machine and plays a role analogous to the familiar Frahm "dynamic damper" for shafts susceptible to torsional vibrations. The absorber as described is adaptable to constant-speed machinery only.

An analysis is made of the use of the absorber with a machine on base mounts symmetrical about a vertical plane through the center of gravity. For the vertical "uncoupled" vibration, an interesting family of curves shows the spread between isolation and resonant frequencies for units of varying parameters. For the more involved case of "coupled" horizontal displacement and rotation about the center of gravity, equations are given for determining the isolation and resonant frequencies together with transmissibilities.

E. J. McBride, USA

1351. Fehrle, L., Critical speed of certain motors with allowance for the gyroscopic effect (in German), *Ing.-Arch.* **24**, 2, 111–123, 1956.

Solution for the critical speed of a shaft using a generalization of a method developed by Grammel is indicated by two equivalent procedures—one utilizing an integral differential equation and the other being based on the conventional differential equation and boundary conditions. A homogeneous disk is mounted on the shaft with its center of gravity coincident with the axis of the shaft, and gyroscopic effects and precession are considered.

G. Murphy, USA

1352. Hosaka, M., Oscillator and shaking table for dynamic calibration of instruments (in Japanese), *J. Japan Soc. mech. Engrs.* **59**, 447, 291–297, Apr. 1956.

Paper describes theory and construction of a new type of shaking table, invented by the author, which generates stable sinusoidal vibrations for a wide frequency range, making use of self-excited vibration. The exciting force is supplied by an electronic feedback circuit in the form of negative resistance, whose nonlinearity is used for the control of the amplitude. Forced shaking of the table is also possible when an adequate oscillator is employed.

S. Fujii, Japan

1353. Vasilieva, R. V., and Fridlyand, V. I., Apparatus for measuring the vibrations of turbo-machines (in Russian), *Sb. Tsentr. n-i, Inst. Tekhnol. i Mashinostr.* 68, 3–10, 1954; Rev. no. 68, *Ref. Zh. Mekh.* 1956.

A description is given of the steady multipoint apparatus developed in the Tsniitmash Inst. for the continuous measurement and recording of the vibration amplitudes of the bearings of steam turbines during starting and running, and also of apparatus for the automatic stopping of the turbine should the amplitude exceed the permissible value. The apparatus enables the measurement and recording to be performed of 10–100 c/s and an amplitude of 0–150μ with an accuracy of 5μ ±5% of the measured value.

Courtesy of Referativnyi Zhurnal I. I. Blekhman, USSR
Translation, courtesy Ministry of Supply, England

1354. Biggs, J. M., and Suer, H. S., Vibration measurements on simple-span bridges, *Nat. Res. Counc. Highway Res. Bd. Bull.* 124, 1–15, 1956.

Paper presents results of field measurements of dynamic deflections of simple-span bridges due to the passage of a heavy vehicle. Data are presented for five bridges of typical design. No strain measurements are presented, and the discussion is limited to a consideration of midspan deflections. Typical dynamic deflection records are shown for the five bridges tested.

The maximum observed amplitudes of vibration for the test bridges vary from 18 to 40% of the maximum static deflection. These amplitudes are considerably greater than would be produced by a theoretical smoothly running load.

The frequencies of the observed vibration while the load is on the span is generally not the natural frequency of the structure but is apparantly related to the natural frequency of the vehicle on its suspension system. Experiments with a vehicle in which the springs had been blocked out of action indicate that considerably larger vibrations occur in this case than in the case of a completely sprung vehicle.

It is concluded that one of the most important factors which influence the vibration of bridges is the dynamic characteristics of the vehicle itself. Another important factor is the condition of the roadway surface on the approaches, which may cause a vibration of the vehicle mass on its suspension system as it enters the span.

Also reported are experiments with a vertical accelerometer which may be used to measure vibrations without reference to a fixed point. The use of an accelerometer is shown to be a satisfactory method for measuring the free vibration of a bridge.

From authors' summary

1355. Podolsky, V. G., Seismic electromagnetic generator for measuring vibrations of small amplitude (in Russian), *Stroit. Prom-St.* no. 8, 44–45, 1954; Rev. no. 70, *Ref. Zh. Mekh.* 1956.

An electromagnetic generator for measuring small oscillations (0.00005–0.1 mm) of building constructions is described. The generator has been constructed on the arrangement of a transformer with a variable gap and is fed by a current of 200-c/s frequency. The core of the transformer (together with the coils) is a seismic mass for the instruments; the armature is rigidly attached to the body. A recording is effected with a C. R. oscillograph (the carrier frequency is recorded, modulated by the recorded oscillation). The amplification of the generator with a U Sh oscillograph (sensitivity 12.5 mm/mA) is 1875. The natural frequency is about 3 cps. The working range is 9–33 cps. A specimen of the recording of the oscillations of the earth of a pile driver is given. There is no information regarding the damping of the instrument.

Courtesy of Referativnyi Zhurnal M. S. Antsyferov, USSR
Translation, courtesy Ministry of Supply, England

Wave Motion in Solids, Impact

1356. Musalov, A. Kh., On a dynamic problem of the theory of elasticity (in Russian), *Trudi Sredneaz. Univ.* no. 54, 107–114, 1954; Rev. no. 401, *Ref. Zh. Mekh.* 1956.

An examination was made of plane dynamic problem of deformation in a right angle, one of the sides of which is free, but the other is given an instantaneous velocity which is constant along the side of the angle. Potentials satisfying the wave equations in the usual way for the displacement vector are introduced. Then author proceeds to nondimensional variables, and reduces the obtained equations to canonical form. The problem posed in the beginning is not solved. Only the following is done: auxiliary functions of the complex variable are introduced for the elliptic case, and conditions are obtained which are derived from the boundary conditions for determination of these functions.

Courtesy of Referativnyi Zhurnal I. S. Arzhanykh, USSR
Translation, courtesy Ministry of Supply, England

1357. Ostashev, N. A., The relationship of the deformation of materials to the time of action of the load, and the rate of its application (in Russian), Kier, 1, d-bo. Akad. arkhitektury, 36 pp., 1953; Rev. no. 398, *Ref. Zh. Mekh.* 1956.

The relationship is discussed between the deformation ϵ and the stress σ for a nonlinearly deformed medium, in the static case. An attempt is made to describe a relaxing nonlinear medium, by means of the reconstruction of A. R. Rzhanitsyn's equation. The left side of the equation is replaced by $\epsilon' + \alpha m t^{m-1}\epsilon$. It is asserted that the solution of this equation with σ = const is

$$\epsilon = \epsilon_{max}[1 - \exp(-\alpha t^m)]$$

The error of this assertion can be proved by simple substitution. Further, instead of ϵ in the expression $\epsilon' + \alpha m t^{m-1}\epsilon$ the following expression is introduced

$$\epsilon = [f(t)/E]\exp\{\delta[f(t)]^m\}$$

where $f(t)$ is the load. It should be noted that this relationship between ϵ and σ (or $f(t)$) has been introduced completely arbitrarily by the author, it occurs in the static case, and for the relaxing medium it is written purely formally if we consider E unknown and not a constant. Nevertheless, when differentiating, ϵE is assumed constant. Thus, all the computations on pp. 13–17 are incorrect. Comparison of the theory with experiments is unconvincing, since the theoretical formulas contain a very large number of undetermined parameters.

Courtesy of Referativnyi Zhurnal A. I. Gubanov, USSR
Translation, courtesy Ministry of Supply, England

1358. Morrison, J. A., Wave propagation in rods of Voigt material and visco-elastic materials with three-parameter models, *Quart. appl. Math.* **14,** 2, 153–169, July 1956.

Paper deals with the determination of the velocity distribution and stress distribution in a semi-infinite rod of a Voigt material and of four three-parameter models, two of which consist of one elastic and two viscous elements while the other two consist of two elastic and one viscous element. A constant velocity or a constant stress is impulsively applied at the end of the rod and subsequently maintained. The problem is solved by the method of Laplace transform.

Paper continues the work of Lee and Kanter [AMR **7,** Rev. 724] and of Glauz and Lee [AMR **9,** Rev. 390].

A. Phillips, USA

1359. Lee, E. H., Wave propagation in anelastic materials, Deformation and flow of solids, Colloquium Madrid, Sept. 26–30, 1955. Berlin, Springer Verlag, 1956. 129–136.

Author and Prof. D. S. Wood of California Institute of Technology have re-examined the original data of a series of experiments on plastic wave propagation at Cal. Tech. [See P. E. Duwez and D. S. Clark, *Proc. ASTM* **47,** 502–532, 1947.] Careful plotting of the residual strain distribution near the impact end of constant-velocity tensile impact specimens failed to confirm the previously reported constant-strain region, predicted by the wave-propagation theory of Kármán based on a stress-strain law independent of strain rate [AMR **4,** Rev. 2481].

Author believes that further development of rate-dependent theories, which do not predict a constant-strain region, is needed to aid in interpretation of experimental work. He compares attempts by this reviewer to consider strain-rate effects [AMR **4,** Revs. 2372, 4088] with more recent work on viscoelastic materials [AMR **7,** Rev. 724]. L. Malvern, USA

1360. Bleich, H. H., and Salvadori, M. G., Impulsive motion of elasto-plastic beams, *Trans. Amer. Soc. civ. Engrs.* **120,** 499–520, 1955.

A normal mode type of analysis is made of the vibrations of free-free beams moving under dynamic forces. The moment-curvature relation is assumed to be linearly elastic up to the limit moment and independent of the rate of loading. Upper bounds on the central hinge angle are calculated on the assumption that a central hinge alone is formed even when the limit moment is, in fact, exceeded away from the center. Impulsive central loading is considered specifically, and a numerical example is given.

D. Drucker, USA

1361. Popov, E. P., Earthquake stresses in spherical domes and in cones, *Proc. Amer. Soc. civ. Engrs.* **82,** ST 3 (*J. Structural Div.*), Pap. 874, 14 pp., May 1956.

Formulas for the primary or membrane stresses in spherical domes and cones due to earthquake loading are given. The earthquake forces are assumed to act in a horizontal direction and in magnitude are equal to a fraction of the dead weight of the structure itself. Such an assumed earthquake loading is commonly used in the design of structures in areas of seismic activity. It is also shown how the ordinary flexure formula may be used directly in determining the meridianal membrane stresses.

From author's summary

1362. Savin, G. N., The dynamic stresses in a mine winding rope when lifting a load (in Russian), *Ukrain. mat. Zh.* **6,** 2, 126–139, 1954; Rev. no. 412, *Ref. Zh. Mekh.* 1956.

The problem of determining the dynamic stresses in a winding rope which is wound on to a drum rotating at a given velocity $v_c = f(t)$ is divided into two stages: (1) Removal of the end load Q from the stationary end. (2) Lifting the load Q in accordance with the given trapezoidal tachogram.

The rope is assumed to be an elastic, viscous rope. Calculation of the internal resistance is based on Voigt's hypothesis. The slipping of the rope over the drum during lifting is neglected. The problem is set of the solution of the well-known equation of motion of the element of the rope

$$\frac{q}{g}\frac{\partial^2 X}{dt^2} = -\frac{\partial T}{\partial x} + q$$

where, in accordance with what has been said above, the function of the stresses

$$T(x,t) = K\frac{\partial u}{\partial x} + \alpha\frac{\partial^2 u}{\partial x \partial t}$$

(α is the coefficient characterizing the damping of the dynamic stresses in the rope) with the following limiting and initial conditions

$$\left(\frac{\partial X}{\partial t}\right)_{x=l} = v_c, \quad u(0,t) = 0$$

$$u(x,0) = \zeta\frac{Q}{K}x + \frac{qx^2}{2K}, \quad \left(\frac{\partial u}{\partial t}\right)_{t=0} = 0$$

(ζ is the nondimensional value indicating the degree of unloading of the winding rope from the end load Q.)

In view of the shortness of time of recording the value r of the end load Q from the stationary end. The problem of finding the function $u(x,t)$ in the first stage of the lift is considerably simplified by neglect of the variation in the length of the rope, and by damping the dynamic stresses in it during the time r. Solving the wave equation which is obtained from this, by D'Alembert's method, author finds the function $u^{(1)}(x,t)$ for the first stage, and the recording time r, and knowing these, he determines the initial values of the required function for the second stage of the lift.

The graphs are given of the relationship of the value $k = cr/l$ to P/Q, ζ and a/g. In this, it is advisable for ease of calculation with the given values of a and ζ according to the given integer values $k = cr/l$ to determine the fractional values P/Q which correspond to them. The following tables are given: (1) The length l_0 of the plumb line of the rope for lifting at given values of $k = cr/l$. (2) The values ζ and $k = cr/l$ for the three values P/Q corresponding to lift with small ($l_0 = 105$m), average ($l_0 = 410$m), and large ($l_0 = 1020$m) depths.

For describing the motion of the system load + lifting rope in the second stage of lifting, the author, using the conception of moments, obtains the integral-differential relationship, on the basis of which, making a first approximation of the solution in the form

$$u(x,t) = x\varphi(t) + x^3\psi(t)$$

he reduces the problem of determining the dynamic stresses in the lifting rope at the second stage of lifting a load from great depths

to integration of the system of two ordinary linear differential equations with variable coefficients.

Courtesy of Referativnyi Zhurnal. Yu. S. Posrol'nik, USSR
Translation, courtesy Ministry of Supply, England

Elasticity Theory

(See also Revs. 1346, 1356, 1357, 1361, 1380, 1391, 1402, 1413, 1447, 1568)

1363. Sato, S., An approach to torsion problem of a circular shaft with multiple-notches, *Rep. Inst. high Speed Mech., Tohôku Univ.* (*B*) 6, 185–199, 1956.

Author investigates multiple, periodic, circumferential notches and regards their depth, period, and radius of curvature as parameters. Graphs represent a numerical evaluation for shafts with grooves of selected pitch and depth. Author points out these shafts are similar to following screw threads: Standard Edison, Round, British Association, and Whitworth. It appears that solutions for solid shafts may be readily applied to hollow shafts and thin tubes provided minimum tube thickness is greater than notch depth. Paper contains formulas and graphs for maximum torsional stress as a function of notch radius and shape.

Author compares his results with those by Sontag and Okuba, and discusses multiple notches versus single notches. Author observes that Okuba's method is more accurate for wide range of notch dimensions as compared with Sontag's formulas.

V. A. Valey, USA

1364. Freiberger, W., Elastic-plastic torsion of circular ring sectors, *Quart. appl. Math.* **14,** 3, 259–265, Oct. 1956.

Exact solution is found for fully plastic stress distribution of ring sectors of any shape by method of characteristics. Inverse method is then used to find exact elastic-plastic solution to an almost-circular section. Starting with known solution of elastic equations containing a single parameter, author determines elastic-plastic boundary by condition $\tau_r^2 + \tau_z^2 = k^2$. Characteristics of plastic solution are then extended outward from elastic-plastic boundary. Any orthogonal projection of these characteristics is boundary of sector for which solution is valid. Use of elastic stress function

$$\Phi = (r^2 - a^2)^2 + (1 - 8a^2)\,(z^2/2)$$

is shown to lead to nearly circular sector boundary if the ratio of ring radius to section radius is greater than six.

P. G. Hodge, USA

1365. Thomas, T. Y., Isotropic materials whose deformation and distortion energies are expressible by scalar invariants, *Proc. nat. Acad. Sci. Wash.* **42,** 9, 603–608, Sept. 1956.

The necessary restrictions for the energy of distortion to be a scalar invariant of the stress tensor are investigated for three cases that may occur in the theory of elasticity or plasticity.

The paper is mathematical in nature and, unfortunately for engineers, no attention is paid to dimensions. Therefore any physical significance that might be attached to a term in one equation may not apply in a subsequent equation.

G. Pickett, USA

1366. Conroy, M. F., The elastic stresses at the boundary of a symmetrically shaped hole in an infinite plate loaded by normal boundary forces in the plane of the plate, *Bull. Calcutta math. Soc.* **48,** 1, 47–54, Mar. 1956.

Author uses the method of N. I. Muskhelishvili for plane stress systems and, by means of a conformal transformation, obtains a solution for a symmetrically shaped hole in an infinite plate due to bands of normal forces not necessarily symmetric with respect to the lines of symmetry of the hole contour. In the solutions so obtained, the resultant moment of the load applied to the body in the transformed plane (which is of interest) does not, in general, vanish, although the resultant force does. Both moment and force vanish in the initial plane and the boundary conditions are set up accordingly.

S. F. Borg, USA

Experimental Stress Analysis

(See also Revs. 1390, 1392)

1367. Vidosic, J. P., Bogardus, F. J., and Durden, J. C., Curved beams with eccentric boundaries, ASME Fall Meet., Denver, Colo., Sept. 1956. Pap. 56-F-1, 5 pp.

A study of curved beams having eccentrically positioned circular-arc boundaries is reported in this paper. The study involves some mathematical considerations as well as a photoelastic investigation of the stresses in such beams. Results comprise a method of design using the ordinary straight-beam theory but involving stress factors. Both curves and expressions that can be used to obtain the required factors are presented.

From authors' summary by H. Beer, Austria

1368. Jacobson, M. A., Bending stresses in spur gear teeth: proposed new design factors based on a photo-elastic investigation, *Instn. mech. Engrs. Proc.* **169,** 33, 23 pp., 1955.

Paper embraces three related subjects: Photoelastic measurement of stresses in spur gear teeth; interpretation of stresses so found to give revised strength factors for B.S. specification on the design of spur gears; and a tentative attempt to correlate the stresses found with fatigue-test results which have been reported by various investigators.

The object of this paper is to propose maximum safe bending loads which involute spur gears can be allowed to carry. The gears investigated are confined to those which can be generated by standard cutters conforming to the 20-deg pressure-angle, B.S. basic rack, without either causing undercutting near the root or undue pointing of the teeth. The values proposed are based on a photoelastic investigation carried out by the author under the guidance of Prof. W. A. Tuplin, at the Post Graduate School of Applied Mechanics, Sheffield University.

Strength factors for spur gears are given in the form of charts. These factors embrace the whole possible range of spur-gear combinations, both with and without addendum corrections.

To enable a rational assessment of strength to be made, a list of service factors, as well as a graph correlating bending-fatigue data for three classes of surface finish (ground and polished, shaved, hobbed), are given. From author's summary

1369. Cheredov, S. V., Wire strain gauge PET-30 m. of the Tsniitmash for measuring static deformation (in Russian), *Sb. Tsentr. n-i. Inst. Tekhnol. i. Mashinostr.* no. 68, 23–32, 1954; Rev. no. 629, *Ref. Zh. Mekh.* 1956.

A strain gage is described which was developed by the instrument section of Tsniitmash for measuring static deformations at 30 points. As a measuring arrangement a nonzero d-c bridge was chosen. At each point, active and compensating strain gages form a half bridge, and 30 balancing half bridges are mounted in the operating panel. Each balancing half bridge made up of 2 strain gages fixed to a plate can be bent by a micrometer screw. This causes an alteration in their resistance of 1–2 ohm. The supply to all the bridges is in parallel from a 6V accumulator with a capacity of 60 to 100 Ah. The reading was made on the scale of a mirror galvanometer (the value of the scale division is not less than 2×10^{-8} A) across the diagonal of the bridge. The range of the measured deformations with strain gages of a sensitivity of 3 = 2 and a resistance of 200 ohm with a feed of 6V, varies between 5×10^{-6} and 2×10^{-3} with subdivision into four ranges. The measuring error was estimated to be not more than 4% of the full

scale value. To improve the stability it is suggested that the arrangement should be previously warmed up for 30–40 minutes.
Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England
M. M. Belyaev, USSR

1370. Scott, I. G., Methods of manufacture of wire resistance strain gauges, *Aero. Res. Labs. Melbourne, Austral. SM Note* 226, 17 pp. + 3 figs., May 1956.

A survey is made of the various methods used for the manufacture of wire-resistance strain gages, both in this country and in the United Kingdom. From author's summary

Rods, Beams, Cables, Machine Elements

(See also Revs. 1319, 1326, 1350, 1363, 1364, 1367, 1368 1370, 1383, 1395, 1397, 1403, 1409, 1445)

1371. Pinsky, M. G., On a method of determining the radius of curvature of a neutral layer of plane curved beams of arbitrary section (in Russian), *Zr. Tomskogo politekhn. Inst.* no. 75, 220–222, 1954; Rev. no. 469, *Ref. Zh. Mekh.* 1956.

A graphical method is given for determining the position of the neutral axis by plotting the reduced section. A similar method was explained in the paper "Novyi metod.rascheta.krivogo.brusa" [see Popov, A., Orlin, A. S., and Ponomerev, S. D., "Calculation of a curved beam," Moscow G.T.T.I. 1933].
Courtesy of Referativnyi Zhurnal A. A. Popov, USSR
Translation, courtesy Ministry of Supply, England

1372. Di Taranto, R. A., A method for determining the flexural effects of statically loaded beams on multiple elastic supports, *J. appl. Mech.* **23,** 4, 503–508, Dec. 1956.

Paper presents equations for finite difference type of arithmetical calculations for beams of variable moment of inertia resting on elastic supports. Method appears suitable for a computing group with no engineering background. G. W. Housner, USA

1373. Stroganov, A. S., Theoretical and experimental investigation of the work of long isolated poles on a horizontal load (in Russian), Laboratoriya Osnovanii i Fundamentov "Vodgeo" (Informatsionnye Materialy no. 4), 1953; Rev. no. 434, *Ref. Zh. Mekh.* 1956.

A method is explained for calculating horizontally loaded isolated poles, this being one of the variations in applying to this problem the theory of calculation of beams on an elastic foundation.

A pole which bends under a load causes, in the upper portion of its encastrement, a soil displacement which extends within the limits of a certain region to a depth z from the surface of the ground, called the "displacement zone." In the lower part of the encastrement, the soil deformations are assumed to be elastic. It is further assumed that the relative linear characteristic of the pole, the work of which within the limits of the "elastic zone" of the soil is identical with the work of a beam on an elastic foundation, is always

$$\lambda_{L-z} = (L - z)/S \geqslant 2.5; \quad S = (4EI/bK)^{1/4}$$

where b is the thickness of the pole, EI the bending rigidity, K the bed coefficient, and L the length of the buried portion of the pole. The author calls this a long pole. In determining the resistance to displacement of the soil, a published solution was used regarding the limiting equilibrium of a body of earth forced out of the soil having a certain spatial form of its outline in accordance with the experimental data. The carrying capacity of the pole is determined from the conditions of its calculation for stability and endurance. In calculating the stability of the pole, it is assumed that the maximum pressure on the soil which occurs, in the author's opinion, at a depth z, which determines the position of the upper limit of the "elastic zone," is equal to the limiting resistance of the soil to displacement at the same depth, found from conditions of the extrusion of the body of earth. In the endurance calculation, it is assumed that the maximum bending moment in the limiting case will be equal to the breaking moment. From the joint solution of two equations, each determining the relation between the transverse force Q and z [(1.) according to the condition of stability of the pole and (2.) according to the condition of its endurance] the required value is found for the load Q_p which causes fracture of the pole. Also, calculation of the deformation of the pole is given, in which its bending is determined, the angle of deflection at a point lying at a depth z below the surface of the ground, and then the displacement of the top end of the pole, on the assumption that it is deflected only in the lower part and remains perfectly rigid in the section above the elastic zone. Further, indications are given for determining the bed coefficient K according to the data from a test of an isolated pole with a horizontal load, and a numerical example is given which illustrates the development of the calculation with the suggested formulas. The resistance of the forced out body of earth is not taken into account. The position of the dangerous section relative to which the value of the greatest bending moment in the pole is determined, is conventionally assumed to be at the depth z from the surface of the ground. The possibility of cutting through the hole in soil by the body of the buried pole is disregarded, which may lead to an incorrect conclusion in estimating the degree of stability of the pole, if the resistance of the soil which is subject to shearing is correspondingly less than the resistance of the soil assumed in calculation to forcing out of the body of earth. Also, a critical review is given of a number of existing methods of calculation of isolated horizontally loaded poles, supplemented by comparison with the experimental data of the value of the breakdown load which is found by calculation by the methods cited, and that recommended by the author.
Courtesy of Referativnyi Zhurnal N. V. Laletin, USSR
Translation, courtesy Ministry of Supply, England

1374. de Caria, P. U., Calculation of coil springs (in Spanish), S. T. A. 8, **28,** 49–54, April 1956.

Author considers a spring in the form of a U-shaped thin elastic wire with additional coils at the base of the U. Assuming the problem to be plane and restricting himself to small deformations, he calculates the displacements of the free ends under the action of two equal and opposite forces in a line of action connecting the ends. Results of this calculation and of experiments are in fair agreement. H. Ziegler, Switzerland

1375. Janossy, F., Influence of elastic deformation on the distribution of pressure in gear teeth, *Gép* **8,** 7, 241–247, July, 1956.

Plates, Disks, Shells, Membranes

(See also Revs. 1339, 1385, 1401, 1405, 1426)

1376. Gaydon, F. A., and Nuttal, H., The elastic-plastic bending of a circular plate by an all-round couple, *J. Mech. Phys. Solids* **5,** 1, 62–65, Nov. 1956.

The complete solution is given for the title problem under the following assumptions: (1) The deformations are sufficiently small so that membrane forces may be neglected. (2) The slopes are sufficiently small so that elementary expressions for curvatures may be used. (3) The plate material is elastic-perfectly plastic with arbitrary Poisson's ratio. The Mises yield condition is used.
P. G. Hodge, USA

1377. De Keyser, R., and Capel, J., Calculation of an oblique slab by the method of finite differences (in French), *Ann. Trav. publics Belg.* no. 4, 5–40, 1955.

The deck plate of an oblique prestressed-concrete bridge (combined highway-railroad bridge) is stiffened by longitudinal and transverse girders, the longitudinal girders consisting of a single girder, two single-box girders and a double-box girder, corresponding to the different loads in the cross section of the bridge (footpath, cycle track, roadway, railway line). The whole bridge represents a frame-like system. The stiffened deck plate is considered as an anisotropic parallelogram plate of variable rigidity with two ends elastically clamped.

Introducing oblique coordinate axes and neglecting Poisson's ratio, the differential equation of the problem is deduced in detail. As it is impossible to find a general analytical solution of such a complicated problem, authors employ the finite-differences method, dividing the parallelogram plate by a net of 5 meshes in the transverse direction and of 9 meshes in the longitudinal direction. Thus results a system of 45 equations with 45 unknowns for each load case, which can be solved using relaxation method.

Numerical results (deflections and bending moments) are represented by diagrams and compared with those of a rectangular plate; the diagrams show a considerable increase of clamping moments in the obtuse angles of the parallelogram plate.

The paper is an interesting and useful example of a particularly complicated skew plate. E. Seydel, Germany

1378. Naghdi, P. M., Note on the equations of shallow elastic shells, *Quart. appl. Math.* **14,** 3, 331–333 (Notes), Oct. 1956.

To the theory of thin shallow elastic shells the author brings additional terms, referring to deformation effects of transverse shear. Cartesian coordinates are used.

H. Neuber, Germany

1379. Kuipers, J., Calculation of a circular cylindrical shell (in Dutch), *Ingenieur, Indonesie* **8,** 1, 3–19, Feb. 1956.

1380. Yakovlev, Yu. V., On the calculation of heat exchange apparatus (in Russian), *Trudi Kharkovsk. aviats. Inst.* no. 15, 133–148, 1954; Rev. no. 382, *Ref. Zh. Mekh.* 1956.

The mechanical calculation of tubular heat exchangers of circular form is examined. The nest of tubes is shown in the form of a complete circular thin plate lying on an elastic base, which prevents both linear and angular displacement of the plate. This enables the influence of the tubes on the deformation of the nest to be considered in an average form. Performation of the plate is taken into account by reduction of the cylindrical rigidity. The problem of the value of the coefficient of reduction depending on the number of holes and their position is not examined. The problem is solved by Bessel functions of a complex independent variable. The tables of these functions are given for values of the argument between 46 and 50°, with an interval of 1°, with a value of the modulus from 0 to 8. The choice by the author of an argument of 46 to 50° is based on the calculations made of the possible value of this argument for a large series of heat exchangers. This more precise method of calculating the apparatus gives results which differ considerably from those obtained on the basis of existing approximation methods.

Courtesy of Referativnyi Zhurnal S. N. Sokolov, USSR
Translation, courtesy Ministry of Supply, England

1381. Nowinski, J., Elementary stress system in a swept thin-walled tube with high taper, *Bull. Acad. Polonaise Sci.* **4,** 1, 3–8, 1956.

In view of the mathematical difficulties encountered in the determination of stresses and strains in swept beams with high taper, author proposes that an elementary "strength of materials" type of approach might often be sufficiently accurate to give an estimate of the order of magnitude of the quantities investigated.

The case treated in detail is that of a thin-walled cantilever tapered tube with rigid diaphragms parallel to the end cross sections. There is no experimental check of the analytical results. The calculated forces along the edges of the horizontal and side walls of the tube were compared with results obtained previously by a more exact treatment. The discrepancies were of the order of 4% and 45%, respectively. Y.-H. Pao, USA

1382. Cleaver, P. C., The strength of tubes under uniform external pressure, *Aero. Res. Counc. Lond. curr. Pap.* 253, 169 pp. + 13 figs., Nov. 1955.

A comprehensive set of experiments was conducted to check the validity of Sturm's solution to the collapse pressure of a tube whose edges are simply supported. The tests covered the ranges of length-to-diameter from 14.0 to 0.51 and diameter-to-thickness of 102 to 17.85. Excellent agreement was shown between experiment and theory.

Results show that the tangent modulus is the only mechanical property which exerts any significant influence on collapse pressure. When the eccentricity of the bore relative to the exterior surface of the tube and the variation in the circularity of the tube were held within specified limits, their effect was small enough to be considered negligible. B. W. Shaffer, USA

1383. Gruber, E., Tube, arbitrarily supported and reinforced with external ribs (in German), *Bautech.-Arch.* no. 10, 21–65, 1955.

A conical circular tube is reinforced by means of ribs along parallels.

Connection between shell and rib n is assumed to prevent only the relative tangential displacement, thus giving rise to stresses $r_n(\phi)$. Membrane stresses are taken into account in the shell; hence tangential displacements $t(\phi)$ of a parallel are derived, due to the applied forces $r_n(\phi)$ and to arbitrary loads on the tube.

The rib is studied as a small curvature beam, submitted to external loads or constraints in its plane and to function $r(\phi)$ applied on a circumference which may not be the central line of the rib. After integration of a differential equation of the sixth order, displacement $t(\phi)$ appears the sum of three terms (*const*, $\text{sen}\phi$, $\cos\phi$) representing rigid movement of the rib in its plane, three terms (ϕ, $\phi\text{sen}\phi$, $\phi\cos\phi$) whose coefficients are determined by the condition of closed circular beam, plus a particular integral which depends on r and the external loads. Noncontinuous loads are also considered.

Statically indeterminate problem is solved by imposing that the displacements $t(\phi)$ of each rib should equal the corresponding ones of the shell; n simultaneous differential equations of the eighth order in the unknown functions $r_n(\phi)$ are thus written.

Fourier developments may transform such system in k systems of algebraic equations: if, in all developments, only the first wave terms are considered, the rib behaves as a rigid one, and the equilibrium equations in its plane relate immediately the unknown coefficients of $r(\phi)$ to those of the external loads on the rib. From the $r_n(\phi)$, thus determined, and the assigned loads on the shell, stresses and displacements of the tube can be calculated. When, instead, the general problem is faced, a transformation allows reducing the number of unknown functions in each differential or algebraic equation.

Calculation is thus developed to a high stage of approximation, overcoming great difficulties due to form of the shell, variety of loads, and great static indetermination of structure.

D. Gentiloni-Silverj, Italy

Buckling Problems

(See also Rev. 1339)

1384. Chilver, A. H., Corrected discontinuities in structural stability problems, *J. Mech. Phys. Solids* **5,** 1, 9–17, Nov. 1956.

Author derives the differential equations for several elementary stability problems by both conventional equilibrium procedures and by his proposed method of corrected discontinuities. The proposed

method equates two systems of external forces on an element of the structure, one system for equilibrium of the element and one system to make the structure continuous. Reviewer believes author's method essentially makes use of a different physical picture to set up the stability equations. Whether the method is shorter than the conventional method will depend upon the particular individual using it. B. E. Gatewood, USA

1385. Baikova, I. P., The influence of angular deformations on the general deformations of weldable panels (in Russian), *Trudi Leningr. politek. Inst.* no. 1, 113–129, 1953; Rev. no. 544, *Ref. Zh. Mekh.* 1956.

The buckling of plates is examined during the welding of butt seams. From the weldable sheets a strip is cut out in a direction perpendicular to the seam. Further, for the band or strip, an equation is formulated for the elastic line, having regard to the forces of the load in the conditions of the given forces and moments (of the displacements and angles of deflection) at the ends of the curved section. The relationships are explained of the length of the curved section to the thickness of the plate and to the angle of deflection at the position of welding. The problem is discussed of the influence of the forces of the intruisic weights of the plates, and of the weight of the compressive loads on the form of the elastic line. All the problems are solved on the assumption of a given angle of deflection of the plate at the weld (in the author's terminology, the angular deformation is given). The influence of the welding conditions on the value of this angle is not considered.
Courtesy of Referativnyi Zhurnal V. I. Feodos'ev, USSR
Translation, courtesy Ministry of Supply, England

Joints and Joining Methods

(See also Revs. 1420, 1442, 1444)

1386. Peattie, K. R., and Pope, J. A., Tests of the bond between concrete and steel. Parts I, II, *Civ. Engng. Lond.* **51,** 596, 181–184, Feb. 1956; **51,** 597, 314–316, Mar. 1956.

Authors describe and analyze three stages: adhesive, frictional, and final. Pull-out and torsion tests are distinguished. Experimental work for both types is described with special reference to the measurements used (1/4 in. long electric resistance strain gages were mounted at 1½-in. centers within a slot of the steel bars). The experimental results for both types of tests are described and discussed, and conclusions are drawn according to which distribution of load and bond stress is exponential during the adhesive stage, whereas in the frictional stage it depends on the frictional force, which decreases if there is a greater relative movement between the two materials. Adhesive bond effect is of greater magnitude for bars with polished surface than the frictional effect. Adhesive effect is limited over relatively short length; consequently for ordinary reinforcing bars, frictional bond is of greater influence, as must be concluded from the full bond resistance ascertained by tests.

This paper seems to be a very valuable contribution to this problem. P. W. Abeles, England

1387. Davidson, J. R., Shear strength at 75° F to 500° F of fourteen adhesives used to bond a glass-fabric-reinforced phenolic resin laminate to steel, *NACA TN* 3901, 21 pp., Dec. 1956.

1388. Navrotsky, D. I., Investigation of the stressed state of double-V welded joints (in Russian), *Trudi Leningr. politek. Inst.* no. 1, 57–69, 1953; Rev. no. 549, *Ref. Zh. Mekh.* 1956.

The results are given of theoretical and experimental investigations of the stress state of a double-V welded joint. The calculation arrangement of the double-V joint is assumed for an infinitely long strip which is subject to a longitudinal and uniformly distributed stress. The distribution of the stresses is investigated in the most stressed part of the double-V joint, at the position of the change of section. Comparison of the calculated and experimental data shows their basic agreement.
Courtesy of Referativnyi Zhurnal E. N. Rakcheev, USSR
Translation, courtesy Ministry of Supply, England

1389. Kraichik, M. M., Brodovich, N. V., The dynamic strength of welded joints having angular seams and electro-rivets (in Russian), *Avtomat. svarka* no. 2, 42–47, 1954; Rev. no. 545, *Ref. Zh. Mekh.* 1956.

Tests were made on specimens of joints used in wagon construction. The authors come to the conclusion that welded joints with angular seams have greater dynamic strength than joints with electro-rivets. S. I. Mikhailov, USSR
Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1390. Sanks, R. L., Two useful gages measure bolt tension and slip in a joint, *Civ. Engng., N. Y.* **26,** 11, 62–63, Nov. 1956.

Structures

(See also Revs. 1338, 1340, 1342, 1354, 1377, 1386, 1421, 1436, 1448)

Book—1391. Kuhn, P., Stresses in aircraft and shell structures, New York, McGraw-Hill Book Co., Inc., 1956, xx + 435 pp. $14.

The subjects treated in this book are divided into two parts: Methods of analysis and Experimental evidence. Under Analysis we find discussed: Elementary theories, Diagonal tension, Shear lag, Two-spar structures, Four-flange shells under torsion, Multi-stringer single cell shells under torsion, Cutouts in plane panels and box beams, and Cutouts in circular cylinders. Under Experimental evidence author presents: Tests and their evaluation, Verification of elementary theories, Diagonal tension tests, Shear lag tests, Torsion box tests, and Cutout tests.

Author treats a difficult subject in a clear, concise, and direct way. It is in formulating the problems and following them to completion that the author shows keen insight into the geometry of deformation involved and the approximations necessary to obtain a working theory.

Reviewer noticed in places that the equation of a fundamental law or a formula would have provided the link between theory and the result given. Larger sketches with more contrast in lines would have made sketches and graphs easier to interpret. In future editions, more complete oblique-view sketches instead of the two-dimensional ones may be an improvement.

The book comes from the able pen of one who has for many years been active in and intimately acquainted with the problems in aircraft structures. Reviewer recommends book to stress analysts and designers of aircraft structures. It is especially useful for those who lack aircraft structures background.
S. Sergev, USA

Book—1392. Elenevsky, G. S., Constructional mechanics of a wing of variable section [Stroited'naya Mekhanika Kryda Peremennogo Secheniya], Moscow, Oborongiz., 1954, 228 pp.; Rev. no. 564, *Ref. Zh. Mekh.* 1956.

The calculation of the stresses and deformations of an aircraft wing are explained, based on the elementary methods of constructional mechanics, applicable to wings of arbitrary thin-walled design. It is based on Bernouilli's hypothesis and assumptions of the absence of the marginal effect of attachment and the load influences of the concentrated load. It is assumed that the longitudinal elements of the wing (the skin and stringers) have a slight inclination towards the longitudinal axis. The calculational arrangement of the wing is selected in the form of a series of concentrated areas, disposed, according to the contour (which take only normal stresses) united by the skin (which takes only the tangential

stresses). The relative effectiveness of the longitudinal elements is taken into account by the reduction coefficients. A contour of the section is considered invariable in its plane. The stresses in the elements of the wing are examined by sections, perpendicular to the axes of the longitudinal elements, and forming skins. The normal stresses of any longitudinal element are expressed by the coefficients which are determined by the cosines of the elements with the axes of the coordinates. These axes are selected in such a way that the longitudinal force relative to them does not tend to rotate the section, and the bending moments acting in the main surfaces do not cause twisting. Bringing the external load to the main axes enables the bending to be separated from the torsion only in the tapered or prismatic wing. In tapered wings, the normal stresses also depend upon the angle of torsion, and the separation of the bending from the torsion in these cases is effected in an approximate form. The real wing, as a result of a small inclination of its elements, should be considered as tapered, and the negligible constraint of the longitudinal deformations should be disregarded, as well as the intrinsic bending and torsional rigidity of the separate elements of the wing. The linear tangential forces are shown in the form of the sum of two basic components: variables of the stresses of the open contour and a constant stress, influenced by the choice of the beginning of the reading and by the torsional moment. In the tapered wing the variable tangential stresses are calculated, which depend not only on the transverse forces, but also on the bending moments, having regard to the inclination of the elements of the wing, and its rigidity. It was shown that determination of the total displacement of the wing section on the basis of these assumptions can be reduced to determination of the linear displacements in each section (short sections) whatever the characteristics of the remaining sections. The displacements are determined with the aid of Castigliano's theorem. The motor tensor of the isolated displacements is formed permitting all the forms of the linear displacements of the separate sections from any combination of loads to be determined, if the 21 rigidity characteristics of the section are known. In the absence of the longitudinal force, it is sufficient to know 15 characteristics, of which the 6 rigidity characteristics are the most essential for determining the bending and torsional deformations.

The general equation of the rigidity axis of the section is given, which is expressed by the characteristics of the bending and torsional rigidities, and by coefficients determined by the cosines of the angles of inclination of the wing elements. By analysis of this equation, certain relationships were determined, and the rigidity factors were obtained which determine the direction of the rigidity axes. Particular cases are given for determining the rigidity axes, as well as the results of the experiments with a two-span wing of one of the aircraft. In appendices, the problems of the influence of the elasticity of the ribs are dealt with, as well as the elasticity of the wing attachment and the introduction of the reduction coefficients, and an example is given.

Courtesy of Referativnyi Zhurnal A. M. Afanas'ev, USSR
Translation, courtesy Ministry of Supply, England

1393. Gentric, A., On landing gear stresses, *NACA TM* 1422, 45 pp., July 1956.

Vibratory phenomena are a new source of landing-gear failures. Paper discusses the following topics:

Preliminary study of test installations: Principle and application of the (landing-gear testing) toboggan and of the vertical (drop test) machine. Excitation of the landing gears in the two cases.

Tangential forces applied to landing gears. Influence on these forces of the moment of inertia of the wheel assembly, of the inflation pressure, of the sliding velocity, of the nature of the rubber constituting the tire, and of the characteristics of the ground. Evaluation of the results obtained in the course of the test. Attempt at generalization. Uncertainty about the value of friction coefficient.

Fore-and-aft oscillations of landing gears. Some examples of forces in the drag strut and of displacements of the wheel axis. Study of the vertical forces. Influence of different factors. Consequence of fore-and-aft oscillations. Examination of various solutions: prerotation of the wheels before landing and longitudinal dashpot.

Examples of fatigue failures resulting from fore-and-aft oscillations.

Possible progress by extensive experimentation, the calculation of vibrations, improvement of existing test equipment, and utilization of new devices. From author's summary

1394. Ojalvo, M., Internal ties in slope deflection and moment distribution, *Proc. Amer. Soc. civ. Engrs.* **82,** ST 6, (*J. Struct. Div.*), Pap. 1096, 17 pp., Nov. 1956.

Author proposes the use of internal imaginary ties to prevent joint translation in the analysis of structures, using "slope deflection" or moment distribution" methods. Reviewer shares author's opinion that use of these ties simplifies analysis of complicated structures (with nonorthogonal members), as the first example in the paper shows. In structures with orthogonal members, reviewer believes that some extra complication occurs in using these ties instead of other known restraints for joint translation. However, it's a valuable idea.

Reviewer thinks that joint translations are not independent of joint rotation and so it is not possible to establish an independent system of equations for the joint translations. This invalidates author's opinion on page 3 (lines 22 to 24). To be able to write equations for joint translations only, as author does on pages 5 and 9, it is necessary to reduce the unknowns to these translations only and this means solving previously the other unknowns (joint rotations for load action and for arbitrary values of joint translations). In other words, author uses as a principal structure one in which joints can rotate but not translate. This way, in the first example for instance, he must solve at least three times (see table 2) the structure with nontranslating joints (10 equations with 10 unknowns each time) and then another system of 2 equations with 2 equations with 2 unknowns. If the complete system of equations is solved, instead of all this work, it would be enough to solve a system of 14 equations with 14 unknowns reduced by symmetry to 6 equations with 6 unknowns, which requires very much less work and time. By complete system of equations reviewer means the system in which all influences among rotations and translations of joints are taken into account simultaneously (see works of K. Beyer and R. Guldan for instance).

A. J. Bignoli, Argentina

1395. Howe, D., and Griffin, K. H., Box beams under constraint, *Engineering* **182,** 4718, 169–174, Aug. 1956.

Paper reviews methods that have been used to determine the stresses in shell structures that are restrained in warping. Further solutions are suggested based on Castigliano's principle of minimum strain energy. The application to swept wings of aircraft is emphasized. The comparison of the calculated and experimental data indicate good agreement for the normal stresses, but not for the shear stresses. Authors indicate a more elaborate theory, including rib flexibility, would improve the accuracy of the calculations. Reviewer comments that such calculations have been made by P. H. Denke of Douglas Aircraft Co. on the IBM Model 701 digital computer. The results show that the incorporation of rib flexibility and additional structural elements result in a worthwhile improvement in the accuracy of the data.

H. H. Dixon, USA

1396. Sandorff, P. E., Design of structural models, with application to stiffened panels under combined shear and compression, *J. aero. Sci.* **23,** 7, 623–632, July 1956.

Structural tests on models are not necessarily to be performed on models which are geometrically similar to the original. For stability tests, for example, if the problem in its generality is left

out, and only some specific modes of failure are taken into consideration, test similarity will require that only some dimensionless parameters be maintained when passing from original to test conditions. A simplified time-and-money-saving technique will result.

An example is made on the column problem; it is also shown that some of the dimensionless parameters can be mutually influenced, and, therefore, a reduced number of them, resulting from their combinations, is to be considered.

Application is then presented to integrally stiffened skin panels under compression and shear. Dimensional analysis leads to establishing dimensionless parameters involved in instability phenomena. It can be proved theoretically that, for all practicable design variations, the isotropic plate of infinite aspect ratio can be considered as a model for stiffened skin panels. Experiments (which are described) have confirmed to a good degree the adequacy of the model.

Other applications are presented, referring to cutout and diffusion problems, general instability of stiffened shells, thermal stresses (for which total energy supply often represents as much of a problem of intensity), and rupture phenomena.

P. Santini, Italy

1397. Ulitsky, I. I., The calculation of certain statically indeterminate rod systems with a mobile load (in Russian), *Sb. tr. Kievsk. inzh-stroit. Inst.* no. 10, 66–77, 1954; Rev. no. 409, *Ref. Zh. Mekh.* 1956.

A method is described of calculating certain symmetrical combined and simple indeterminate systems with a mobile load.

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1398. Oaks, J. K., and Hovell, P. B., Some work on tension pads for structural tests, *Aero. Res. Counc. Lond. curr. Pap.* 238, 11 pp. + 5 figs., 1956.

Sorbo rubber tension pads glued with Bostik adhesive have been developed for loading aircraft components during static and fatigue strength tests. The glueing technique, detail tests, and pilot test on a typical component are described. A safe working stress for this type of pad is suggested. An account is given of some component approval tests in which tension pads were used.

From authors' summary

1399. Barnoff, R. M., Simplified analysis of rigid frames, *Proc. Amer. Soc. civ. Engrs.* **82,** ST 6, (*J. Struct. Div.*), Pap. 1106, 19 pp., Nov. 1956.

Formulas and graphs are derived for frames having either 2 or 3 equal columns with or without hinges at the bottom under vertical or lateral loads. In reviewer's opinion, the information given in the paper can be found in any up-to-date designers' handbook.

H. Craemer, Germany

1400. Kagan, S. A., Investigation of the deformation of multistory frames of high buildings by horizontal loading (in Russian), Issled. konstrucktsii vysotnykh. adanii, Moscow, Gos. izd-vo. lit-ry. po str-va. i Arkhitekture 80–103, 1953; Rev. no. 446, *Ref. Zh. Mekh.* 1956.

A method is suggested for the approximate determination of absolute and relative horizontal displacements of any story of a multistory multispan frame which is loaded by a wind loading. Good agreement with the results of the calculations by other methods is found. An experimental check is made on models of 18 to 25 story frames, having between 1 and 9 spans.

Courtesy of Referativnyi Zhurnal L. N. Vorob'ev, USSR
Translation, courtesy Ministry of Supply, England

1401. Gornov, V. N., Investigation of the static work of wall and partition panels (in Russian), Issledovaniya Prochnosti, Zhestkosti i Ustoichivosti Krupnopanelnykh Konstruktsii, Moscow, Gos. izd-vo Lit. po str-va i Arkhitekture 7–38, 1954; Rev. no. 506, *Ref. Zh. Mekh.* 1956.

A method is suggested for calculating compressed, bent elastic, reinforced supporting walls of light and heavy concrete frameless buildings. An experiment is described of the compression of 6 ferroconcrete square plates, each of which is a model of a supporting wall of 1/3 natural size. Tests have shown that the carrying capacity of the wall with 2 free vertical edges, and of a wall with one hinged and one free vertical edge, are approximately identical. Walls having all four edges hinged have a considerably greater carrying capacity. In addition, the test showed that the destruction of the walls occurred from using the strength of the elongated zone during bending. K. S. Zavriev, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1402. Shestov, B. S., The problem of the static calculation of elastic bunkers (in Russian), *Promyshlemnye, Zdaniyia. i. sooruzheniya Moscow. Ugletchizdat* no. 1, 133–140, 1954; Rev. no. 525, *Ref. Zh. Mekh.* 1956.

The wall of an elastic bunker is considered as a cord loaded with vertical and horizontal pressures, each of which is proportional to the distance from the free surface. The solution is given by the aid of elliptic integrals. An approximate method is indicated for calculating a bunker with a curved envelope.

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1403. Jager, K., Bending stiffness of reinforced-concrete beams; theory and experiments (in German), *Öst. Bauzeitschr.* **11,** 9, 195–203, Sept. 1956.

Based on elastoplastic theory author derives expressions for curvature of reinforced-concrete beams under bending moment and hence obtains formulas for flexural rigidity of singly and doubly reinforced rectangular sections under working loads and at ultimate collapse. Theoretical relationships are compared with tests on some simply supported beams under third-point loading and fair agreement is found throughout the loading range.

G. G. Meyerhof, Canada

1404. Lee, L. H. N., Inelastic behavior of reinforced concrete members, *Trans. Amer. Soc. civ. Engrs.* **120,** 181–207, 1955.

On the basis of his studies, author concludes that under short-time static loading, the parabolic stress-strain relation for direct compression may be used to obtain the moment-curvature relation for beams. Ultimate load-carrying capacity is computed for indeterminate beams using the full moment-curvature relation. Tests on three beams check theory remarkably well.

D. C. Drucker, USA

1405. McComb, H. G., Jr., Stress analysis of circular semi-monocoque cylinders with cutouts, *NACA Rep.* 1251, 55 pp., 1955.

An airplane fuselage often has doors, windows, access holes, or other openings which create discontinuities in the structure. The stress distribution in their vicinity is of much interest to the stress analyst. The method of analysis described consists of superposition of the stresses which exist in the structure without a cutout and those perturbation stresses which are necessary to annihilate the effects of the basic structure which lies within the cutout boundaries. The perturbation solutions are obtained by use of the principle of minimum complementary energy. The energy of axial distortion of the stringers, the shear energy in the sheet, and the bending energy of the rings in their own plane are considered. The stringer loads are expressed in the form of a finite trigonometric series, the coefficients of which are written in terms of the shear flows and ring bending moments. Substituting these expressions into the minimized stress energy equation yields a fourth-order finite difference equation which can be solved.

The method can be used for any loading for which the stress distribution in the structure without a cutout is known. Tables of coefficients for the perturbation stresses are given for a wide range of structural properties. Sample calculations are shown.
A. D. Topping, USA

1406. **Warshaw, S. I., Pre-stressed ceramics,** *Bull. Amer. Ceram. Soc.* **36,** 1, 28–29, Jan. 1957.

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1358, 1360, 1364, 1365, 1404, 1432, 1439, 1450, 1452, 1540)

1407. **Mellor, P. B., Stretch forming under fluid pressure,** *J. Mech. Phys. Solids* **5,** 1, 41–56, Nov. 1956.

Results of experiments on hydrostatic bulging of circular metal diaphragms are reported. The experimental procedure and the precautions taken to insure accuracy are described in detail.

The investigation had as its aims a comparison of the strain geometry with that predicted by theory, use of the test to obtain strain-hardening characteristics for sheet metal, and to ascertain to what extent theory is capable of predicting the condition of instability.

The predicted strain distribution is confirmed by experimental results but theoretical and experimental results for the onset of instability show little correlation.

The use of the test to obtain strain-hardening characteristics is shown to be practicable, but the method is tedious and unlikely to displace tests now in use. F. Ellis, England

1408. **Sveshnikova, V. A., Plastic deformation of hardening metals** (in Russian), *Izv. Akad. Nauk SSSR, Otd. tekh. Nauk* no. 1, 155–161, Jan. 1956.

Paper describes and interprets combined-stress experiments of two types on thin tubes of copper, brass, and duralumin: (a) specimen, after preliminary plastic stretch, is twisted under constant tension σ; (b) specimen, after preliminary plastic twist, is stretched under constant torsional shear stress τ. In each case, elongation e and shear strain γ are measured. Ratios τ/γ in (a) and σ/e in (b) are compared with predictions of usual forms of flow theory (Prager) and deformation theory (Ilyushin); agreement is poor. In (a) there is better agreement with slip theory (Batdorf and Budiansky); its predictions in (b) are not given. Changes of e with τ in (a), and of γ with σ in (b), give strain-to-stress ratios comparable with γ/τ and e/σ, whereas usual flow and deformation theories predict zero. Author successfully calculates these changes from the other data of the experiments by a form of flow theory in which curve $\phi(\sigma, \tau) = 0$, describing state, intersects σ and τ axes obliquely. William Fuller Brown, Jr., USA

1409. **Mirolyubov, I. N., Calculation of the endurance of non-homogeneous linearly stressed rods, having regard to the plastic deformation** (in Russian), Trudi Leningr. voenno-mekhan. Inst., H. L. Mashgiz. no. 1, 34–59, 1954; Rev. no. 394, *Ref. Zh. Mekh.* 1956.

The problem is examined, on the usual assumptions, of the calculation of rods for elongation, compression, and bending. The hardening is assumed to be linear and also the case of absence of hardening is examined.
Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1410. **Postnikov, V. S., Measurement of the internal friction and the modulus of rigidity, creep and relaxation stress in constant deformation** (in Russian), *Sb. Nauk Trudi Kemerovsk. gorn. Inst.* no. 1, 211–224, 1954; Rev. no. 616, *Ref. Zh. Mekh.* 1956.

A method is described of measuring the internal friction, the rigidity modulus, the reverse creep, and the relaxation stresses during torsion with small stresses. In this, the measurements are made on the same instrument for a wide range of temperatures. The measuring equipment consists of a vacuum relaxer, thermo-regulator, and an optical system. The vacuum relaxer is a T. S. Ke. instrument of improved design. The thermo-regulator is a resistance bridge, one of the branches of which is a platinum resistance placed in the heating furnace. A galvanometer is put in the bridge circuit, the pointer of which controls the aperture of a photo-electric cell, and the latter, by means of a one-valve amplifier, controls the operating relay. The accuracy of the temperature regulation is $\pm 0.25^\circ$ and may easily be increased up to 0.05°. The optical system consists of a light source, a concave mirror with a focal length of 250 mm, attached to the lower clamp of the test specimen, a calibrated scale which is separated by 3 flat mirrors from the spherical mirror to a distance of 4 m.
Courtesy of Referativnyi Zhurnal V. F. Mivskov, USSR
Translation, courtesy Ministry of Supply, England

1411. **Mikeladze, M. Sh., Plastic state of a rotating anisotropic solid cylinder** (in Russian), *Prikl. Mat. Mekh.* **19,** 4, 504–506, July/Aug. 1955.

Brief development of the equations for incompressible radial flow and constant longitudinal strain, well-known in the case of isotropic material. The basic equations are taken from Hill ["Mathematical theory of plasticity," Oxford 1950], and the von Mises-Hencky condition, modified for anisotropy, is used. Author concludes that a certain type of anisotropy will raise the angular velocity at which plastic flow commences. The elastic solution for a rotating cylinder of anisotropic material is also given.
F. C. Roesler, England

1412. **Ericksen, J. L., Overdetermination of the speed in rectilinear motion of non-Newtonian fluids,** *Quart. appl. Math.* **14,** 3, 318–321 (Notes), Oct. 1956.

Author points out that, in the case of rectilinear motion with constant speed, Reiner's theory of non-Newtonian fluids as specialized by Rivlin for incompressible fluids [AMR **2,** Rev. 1024] yields two partial differential equations for determining one single unknown, namely the speed. These two equations are, in general, independent, and then only such types of motion are possible that curves of constant speed are either circles or straight lines. This limits rectilinear flow to certain shapes of the cross section of the tube through which the flow takes place. No information is shed on what types of motions replace the rectilinear flow when cross sections are of other shapes. M. Reiner, Israel

1413. **Prager, W., Thermal stresses in viscoelastic structures,** *ZAMP* **7,** 3, 230–238, 1956.

Paper represents a slight generalization of that part of this reviewer's analysis of thermal stresses in viscoelastic media [A. M. Freudenthal: *J. appl. Phys.* **25,** p. 1110, 1954; von Mises Memorial Volume, Academic Press (1954) p. 251; *J. aero. Sci.* **21,** p. 772, 1954] that is concerned with a simple model truss of a type introduced by Hencky for the study of inelastic response. The conclusions reached are in no way different, as is illustrated by the similarity of Fig. 4 of the paper with Fig. 2 of the second reference cited. A. M. Freudenthal, USA

Failure, Mechanics of Solid State

(See also Rev. 1437)

1414. **Rokhlin, I. A., On the impact toughness and fatigue of building ceramics** (in Russian), *Steklo i Keramika* no. 7, 14–17, 1954; Rev. no. 597, *Ref. Zh. Mekh.* 1956.

The necessity is pointed out of knowing the strength properties to shock of a ceramic when designing a series of building compo-

nents which are subject to impact loading during assembling or in service, and also when determining the endurance of ceramic paving stones for bridges, vehicle transport loads. A description is given of the basic methods of testing stones with repeated or single shocks. Tests are made of ceramic specimens for impact bending and fatigue during repeated impacts. The tests were made in the scientific research institute for building technology of the architectural academy of the Ukranian SSR. Parts of thin-walled hollow-bodied ceramic bricks were tested which were made in factory conditions by the plastic moulding method on a band press. The dimensions of the specimens were 30 × 12 × 100 mm. The results of the ceramic tests are given for repeated impact compression. The specimens which were sawed out of the walls of ceramic bricks were of cubic shape with a side of 1 cm, with carefully polished faces. Tests were also made to determine the reduction in the limiting strength of the ceramic under the influence of repeated impacts. The corresponding experimental points lie well on a parabolic curve. N. I. Chernyak, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1415. Tarutin, A. A., Increase in the fatigue strength of leaf springs by the method of plastic upsetting (in Russian), *Sb. N.A.M. I.* no. 68, 1–28, 1953; Rev. no. 542, *Ref. Zh. Mekh.* 1956.

The results are given of the experimental investigation of the influence of preliminary plastic upsetting of leaf springs on the increase of their fatigue strength. Calculation is given of the stresses which occur in the plastic upsetting of the spring, and a method is described of upsetting an assembled spring pack. It was shown that the effectiveness of strengthening the spring by plastic upsetting is dependent on the characteristic of the stress cycle, which increases with reduction of the amplitude of the cycle. The optimum values of the stresses during upsetting are explained.

Courtesy of Referativnyi Zhurnal L. E. Andreeva, USSR
Translation, courtesy Ministry of Supply, England

1416. Rightmire, B. G., Statistical analysis of a wear process, ASME-ASLE Lubrication Conf., Atlantic City, N. J., Oct. 1956. Pap. 56-LUB-10, 8 pp. + 1 fig.

The paper is a first attempt at the formulation of a statistical theory to explain wear in a rubbing or sliding process. The results of Kerridge's experiments [M. Kerridge, *Proc. phys. Soc. (B).* **68,** 400, 1955] are interpreted by assuming that wear is the result of "successful" rubbings between slider and ring, such successes being chance events, that the rate of transfer of "spots" per revolution is constant, that no wear occurs during an "incubation" period, and that the same mass is transferred during each successful rub. The incubation period is associated with the formation of α-Fe_2O_3 which appeared as the wear particles in Kerridge's experiments. While the theory can be made to gain rather good agreement with the experimental results, the number of parameters required would seem to classify the theory as an ad hoc one which will, however, be of importance in guiding further experiment. The assumptions made to estimate the probability of a successful rub appear to be over-simplified. The actual values for the probabilities of successful rub and other parameters which are used to show that the theory is in agreement with experiment do not appear to be related to the values estimated by the author previously.

E. Koenigsberg, USA

1417. Kol'chenko, A. V., Study of turbodrill abrasion wear caused by weighted clay mortar (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 1, 21–29, Jan. 1956.

1418. Feng, I.-M., An experimental study of fretting, Instn. mech. Engrs., Preprint, 8 pp.

A new technique for visual examination of the progressive development of fretting is evolved and found to be especially useful in following the progress of fretting from the initial stage to the later stages. The qualitative investigation, coordinated with a quantitative study in three different atmospheres, dry air, carbon dioxide, and helium, yielded results supporting the mechanism of fretting suggested by the author in a previous publication. This observation also leads to the conclusion that chemical reaction, for example oxidation, of metal with the environment takes place while the metal is being removed, or after it has been removed, from the surface. From author's summary

1419. Halliday, J. S., The measurement of frictional forces at vibrating contacts, *J. sci. Instrum.* **33,** 6, 213–217, June 1956.

A simple machine is described which is used for the investigation of wear phenomena at vibrating contacts. It is shown theoretically how frictional forces at the contacts can be measured, and experimental tests substantiate the theory. Some friction measurements are given which were obtained using brass specimens immersed under silicone oils having a wide range of viscosities. It was found that the friction was least for the medium viscosity oils. The higher friction with the high viscosity oils are because these oils were pushed aside from the contacts, and with the lowest viscosity oils because they were not as effective in preventing the growth of intermetallic welds as the medium viscosity oils. From author's summary

1420. Field, J. E., Fretting corrosion on a screwed joint under prolonged fatigue loading, *Engineer, Lond.* **200,** 5196, 301–302, Aug. 1955.

Numerous cases are known, both in service and in the laboratory of fatigue cracks which have commenced at an area of fretting corrosion, such as often occurs when two parts in contact are subjected to a small relative oscillatory movement. This fretting corrosion can considerably reduce the inherent fatigue resistance of a part subjected to fluctuating stresses. Here tests of fretting corrosion on a screwed connection are described. The conclusion is drawn that the fatigue strength of a bolt is not adversely affected. From author's summary

1421. Hoff, N. J., Experiment and theory in the investigation of the behavior of structures at high temperatures, *Aero. Engng. Rev.* **15,** 2, 39–47, Feb. 1956.

An account is given of the problems of creep, thermal stresses and buckling in consequence of creep or thermal stresses, which arise from aerodynamic heating in the structural components of supersonic aircraft. From author's summary

1422. Hoke, J., and Eberle, F., Experimental superheater for steam at 2000 psi and 1250 F—report after 14,281 hours of operation, ASME Ann. Meet., Chicago, Ill., Nov. 1955. Pap. 55-A-102, 11 pp. + 10 tables + 15 figs.

In order to investigate the reactions of superheater alloys to operating conditions producing steam at 1250 F, a test element constructed of 2-in-OD alloy tubes was installed in an operating boiler at the Twin Branch Plant. Operating conditions and experience after 5000 and 12,000 hr as well as metallurgical examination of specimens removed from the element after nearly 7000 hr of operation were described in previous papers. The present paper describes the results of the metallurgical examinations after 14,2[illegible] hr of operation, when the experiment was discontinued and the test element removed for complete examination and evaluation.

From authors' summary

1423. Gruzdev, V. N., Structural defects in the DKV-6, 5-13 boiler (in Russian), *Teploenergetika* **3,** 1, 61–62 (Letter to the Editor), Jan. 1956.

1424. Geguzin, Ya. E., and Ovcharenko, N. N., Investigation of some physical processes occurring on metal surfaces at high temperatures. Part 1: "Natural surface roughness" of polycrystals (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 1, 108–118, Jan. 1956.

1425. Ilschner, B., Calculation of diffusion processes at varying temperatures (in German), *Arch. Eisenhüttenw.* **27,** 5, 337–342, May 1956.

Diffusion in alloys during a process of cooling, including possible solidification, can frequently be regarded as diffusion on one dimension, the diffusion coefficient D depending, by way of the temperature T, on the time t but being independent of the coordinate (x). In this case the concentration c is determined by an equation of the form

$$\partial c/\partial t = D(t)[\partial^2 c/\partial x^2]$$

This equation can be solved by employing solutions of the ordinary diffusion equation; it is merely necessary to change the time scale, so that the original Dt is replaced by $\int_0^t D(t)\,dt$. By this method author derives relations specifying the progress of diffusion; in order to obtain closed expressions the assumption is made that log D is proportional to $-1/T$ and that T depends upon the time and a parameter b according to

$$T(t)/T(0) = 1 + bt$$

Results are applied to problems in metallurgy, in particular to solutions of silicon or carbon in iron and the oxidation of iron near the surface. Author's work provides a useful tool for computation; it has the merit of its mathematics being simple.

R. Eisenschitz, England

1426. Peters, R. W., and Dow, N. F., Failure characteristics of pressurized stiffened cylinders, *NACA TN* 3851, 18 pp., Dec. 1956.

1427. Cottrell, A. H., Dislocations in crystals, Deformation and flow of solids, Colloquium Madrid, Sept. 26–30, 1955, 33–52. Berlin, Springer Verlag, 1956.

A short review of the dislocation theory of plastic deformation, with emphasis on the probable mechanism of work-hardening.

J. C. Fisher, USA

Material Test Techniques

(See also Rev. 1443)

1428. McGonnagle, W. J., Some nondestructive testing methods for testing welds, *Welding J.* **35,** 11, 1110–1119, Nov. 1956.

The sensitivity, advantages, disadvantages, and limitations of the various methods and techniques of nondestructive testing are discussed. From author's summary

1429. Armstrong, C. C., Ulp, R. B., and Larson, K. C., Sonic method proves valuable for testing concrete specimens, *Civ. Engng., N. Y.* **26,** 11, 58–61, Nov. 1956.

1430. Chaturvedi, D. C., Gupta, G. C., and Srivastava, H. D., Investigation of the properties of concrete by non-destructive method (sonic apparatus), *J. Instn. Engrs., India* **36,** 8(part 1), 1645–1655, Apr. 1956.

1431. Ratner, S. B., and Reznikovsky, M. M., A method of testing rubber and methods of artificial aging (in Russian), *Zabod. Lab.* **20,** 7, 849–963, 1954; Rev. no. 614, *Ref. Zh. Mekh.* 1956.

This is a survey of work on the evaluation of the most important physical-mechanical properties of rubber. Methods are explained of physical-mechanical tests which are used in the scientific research institute of the rubber industry and in the scientific research institute of the tire industry. The disadvantages are pointed out of the generally known methods of testing and recommendations are made for their improvement.

Authors classify the tests according to the following criteria: (1) static deformability, this refers to the determination of the elastic modulus of rubber in radial and two-dimensional compression, the determination of the relaxation properties, and the strength of the rubber. (2) Dynamic deformability, the determination of the dynamic modulus, the hysteresis properties and the strength of rubber. (3) The mechanical action on rubber of bodies which are in contact with it. To this group applies the method of determining the strength of the bond between layers, the determination of the coefficient of friction, and the abrasion index of the rubber. (4) Frost resistance; methods are described of estimating the frost resistance, according to the deformability, the regeneration capacity, brittleness, shrinkage, and crystallisation. Methods are explained for accelerating the aging of rubber: heat, light, ozone, and light plus ozone. A number of arrangements are shown of the recommended equipment. N. V. Zakharenko, USSR

Courtesy of Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

1432. Hayward, D. C., A fixture for testing sheet materials in compression at elevated temperatures, *J. roy. aero. Soc.* **60,** 550, 669–674, Oct. 1956.

1433. Leech, E. A., Gregory, P., and Eborall, R., A hot impact tensile test and its relation to hot-working properties, *J. Inst. Metals* **83,** 347–353, 1954–55.

A simple attachment to a standard Izod impact machine permits tensile test pieces to be broken at strain rates of about 250 sec^{-1}. By mounting a furnace close to the machine, tests can be carried out at a high temperature by rapidly transferring the specimen from the furnace to the anvil of the machine.

The behavior of a variety of copper-base materials in the test has been compared with their known working behavior. A comparison has also been made between the ductility shown by a bronze in the test and its liability to edge cracking in hot rolling at various temperatures. From authors' summary

1434. Soxman, E. J., Tinklepaugh, J. R., and Curran, M. T., An impact test for use with cermets, *J. Amer. ceram. Soc.* **39,** 8, 261–265, Aug. 1956.

Several specimens of a commercially produced nickel-bonded titanium-carbide cermet were tested in eight laboratories at room temperature and at 1800 F by an increment-type impact test in which the specimens were held as a cantilever in a vise and were subjected to repeated blows of increasing intensity at their free ends. The inconsistent results obtained were attributed to differences in (1) vise jaw insert material and design, (2) vise gripping pressure, or (3) the stress condition of the specimen at elevated temperatures as contrasted with that at room temperature. A different increment-type impact test was developed and was used for evaluating the low-velocity impact behavior of cermets as a function of temperature. In this test the specimens were supported at their ends and were subjected to impact loading at their midpoints by a freely falling hammer. Hot tests were conducted on specimens heated by means of their electrical resistance. The test was modified, by the addition of a miniature muffle furnace, for testing electrical insulators at elevated temperatures. It was established that increment impact tests, when used with metal-bonded cermets, are subject to a repeated-blow effect; i.e., low-energy blows contribute not only to recoverable elastic deformation but also to some permanent damage. In spite of this complication, the new test has been tentatively accepted for use by several cermet research laboratories. From authors' summary

1435. Miller, J. A., and Albert, A. L., Mechanical tests on specimens from large aluminum-alloy forgings, *NACA TN* 3729, 25 pp., Aug. 1956.

Results of tensile and bend tests on specimens in the T6 condition from 12- by 12- by 24-in. hand forgings of 7075 (75S) and 2014 (14S) aluminum alloy are presented in this report. Thirty-six notched bend specimens were tested as cantilever beams, together

with 48 tensile specimens of material adjacent to the bend specimens. Two-thirds of the bend specimens were 1/4 in. wide. In these, the critical extreme fiber stresses were unidirectional. The rest of the bend specimens were 6 in. wide. In the latter, there were biaxial stress conditions at the critical extreme fiber. The specimens were taken in the axial direction and in both transverse directions. Photogrids were applied to all specimens. The photogrids were photographed at frequent intervals during each test to provide a record of the progress of deformation.

Marked differences were found in the results of tensile tests on specimens in different directions and from different locations in the billet. Corresponding differences were found in the results of the bend tests.

Comparison of the results for the 1/4-in. and 6-in. bend specimens showed that, on the average, the biaxial stress conditions in the 6-in. specimens caused the strain at failure to be about 0.3 that of the 1/4-in. specimens. For the narrow bend specimens the strain at failure over a 0.1-in. gage length at the root of the notch was found to be from 26% less to 150% greater than the average strain observed in the region of fracture of adjacent tensile specimens.

It was found that the use of the average tensile strength of material adjacent to the bend specimens as a modulus of rupture in design gave strengths from 33 to 43% less for the narrow bend specimens and from 18 to 43% less for the wide bend specimens than those obtained in the bend tests. When the average tensile strength in the direction of the bend specimen was used as modulus of rupture the strengths were from 33 to 44% less for the narrow specimens and from 17 to 43% less for the wide specimens than those obtained in the bend test.

The ratio of modulus of rupture to tensile strength for low-elongation material increased with increase in strain at failure of the bend specimens and with increase in strain at failure of the adjacent tensile specimens. From authors' summary

1436. Suddarth, S. K., A hydraulic test facility for timber structures, *For. Prod. J.* **6,** 5, 4 pp., May 1956.

Mechanical Properties of Specific Materials

(See also Revs. 1387, 1398, 1406, 1408, 1414, 1431, 1433, 1434, 1435, 1453)

1437. Wells, A. A., The brittle fracture strengths of welded steel plates, *Trans. Instn. nav. Arch. Lond.* **98,** 3, 296–326, July 1956.

An account is given of a series of tensile tests on wide mild steel plates of 1-in. thickness, where the plates contained central, notched butt welds parallel to the direction of pull. The notches consisted of fine, shallow sawcuts made in the plate edges prepared for welding, and were intended to simulate weld flaws. The tests were conducted within the temperature range ± 15 C, which was below the fracture appearance transition temperature of the parent material.

At temperatures above 4 C, the plates sustained yield point average static tensile stresses before brittle fractures occurred. Below 4 C, brittle fractures across the weld residual stress zones started from the sawcuts, either spontaneously after welding, or with small external loads. With continued loading, complete fractures were obtained only after general yield of the remaining plate cross sections. At 4 C, a single stage fracture was produced at half yield point stress. In further tests between ± 15 C no residual stress-zone fractures could be produced at less than yield point stresses in welded plates previously stress relieved by stretching at 40 C.

Considerable importance is attached to the critical temperature, at which alone complete fracture could be obtained at half point stress. The Charpy V-notch energy of 7 ft lb at this temperature matches the energy range identified by Williams for casualties in American welded ships. Evidence is presented to show that the behavior in these tests may be explained mainly in terms of the mechanical effects of weld shrinkage and residual stresses, and metallurgical damage over the narrow weld-hardened zone. From author's summary

1438. Heimerl, G. J., Kurg, I. M., and Inge, J. E., Tensile properties of Inconel and RS-120 titanium-alloy sheet under rapid-heating and constant-temperature conditions, *NACA TN* 3731, 29 pp., July 1956.

Results are presented of rapid-heating tests to determine the tensile strength of Inconel and RS-120 titanium-alloy sheet heated to failure at uniform temperature rates from 0.2F to 100F per second under constant load conditions. Yield and rupture stresses, obtained by rapid heating, are compared with yield and ultimate stresses from elevated-temperature tensile stress-strain tests for 1/2-hr exposure. The applicability of master curves and temperature-rate parameters to the prediction of yield and rupture stresses and temperatures under rapid-heating conditions was investigated. From authors' summary

1439. Mathauser, E. E., Compressive stress-strain properties of 7075-T6 aluminum-alloy sheet at elevated temperatures, *NACA TN* 3854, 54 pp., Nov. 1956.

1440. Mathauser, E. E., Compressive stress-strain properties of 2024-T3 aluminum-alloy sheet at elevated temperatures, *NACA TN* 3853, 66 pp., Nov. 1956.

1441. Furukawa, G. T., Douglas, T. B., McCoskey, R. E., and Ginnings, D. C., Thermal properties of aluminum oxide from 0° to 1,200° K, *J. Res. nat. Bur. Stands.* **57,** 2, 67–82, Aug. 1956.

Accurate measurements of the heat capacity of α-aluminum oxide (corundum) from 13 to 1,170K are described. An adiabatic calorimeter was used from 13 to 380K and a drop method was used with a Bunsen ice calorimeter from 273 to 1,170K. The results are compared in the range 273 to 380K, where the two methods overlap. From the data, smoothed values of the heat capacity, enthalpy, entropy, and Gibbs free energy from 0 to 1,200K are derived and tabulated. From authors' summary

1442. Miller, M. A., and Mason, E. W., Properties of arc-welded joints between aluminum and stainless steel, *Welding J.* **35,** 7, 323s–328s, July 1956.

Tensile, bursting, and fatigue strengths of argon-shielded tungsten-arc-welded joints between 3004-0 tube and aluminum-coated type 304 stainless-steel tube approximated the typical strengths of unwelded 3004-0 tube of the same dimensions. Shear strengths of tungsten-arc-welded tube joints between 6061-T6 and aluminum-coated type 304 stainless steel were only a little lower, when made with 4043 filler metal, than the typical shear strength of cast 43 alloy.

The effect of postheating on the shear strength of aluminum-steel joints made in various ways indicates that welded tube joints might operate safely at temperatures up to 500F for long periods of time without serious loss of shear strength. Thermal shock cycling tests between room temperature and 500F on brazed aluminum-type 347 stainless-steel joints suggest that arc-welded joints between aluminum and stainless-steel tubes will be able to withstand this type of treatment without damaging effect.

Available data indicate that aluminum tube-stainless steel tube joints will have an adequate resistance to corrosion in many environments. From authors' summary

1443. Pomeroy, C. D., and Morgans, W. T. A., The tensile strength of coal, *Brit. J. appl. Phys.* **7,** 7, 243–246, July 1956.

Apparatus is described which has been developed for the measurement of the tensile strength of coal by bending thin

strips. Measurements on four coals show that the strength depends on type of coal and on direction of loading relative to the bedding planes.

One coal has been studied in some detail and the tensile strength is shown to decrease with increasing size of specimen. The effect is attributed to the increased probability of finding in larger specimens a weakness which imparts a low strength. It is estimated that, for a given size of specimen, the tensile strength is of the order of one-tenth of the compressive strength.

Further, it has been found possible to rejoin broken strips of this coal so that up to ten successive tensile tests can be performed on a single strip, thus enabling the distribution of the weaknesses to be studied. In general, there is an increment of strength between successive breakages, and after ten breaks the tensile strength is roughly double the value obtained at the first break. This method of studying distribution of strength does not appear to have been used previously, although it is likely to have applications to many other brittle materials.

From authors' summary

Book—1444. Timber Engineering Company, Timber design and construction handbook, New York, F. W. Dodge Corp., 1956, 622 pp. $11.50.

Leaders in the field of timber design and construction compiled their knowledge and know how in this illustrated handbook on design procedures and construction practices, to provide a concise source of reference for the student as well as the practicing architect, engineer, builder, and contractor.

The publication of this handbook filled, to a certain extent, a long-felt need for such a compilation of this information. Previous to its publication, many of the data were available only to relatively few specialists particularly active in the field of wood construction and timber engineering, who had an opportunity to digest the numerous sources of information found in the research files and publications of public and private laboratories, as well as in the volumes of quite a number of technical magazines and trade journals.

Consisting of thirteen chapters and supplemented by a short glossary, list of common abbreviations, and brief index, the text can be divided into three principal sections: (1) basic properties of wood, (2) design, fabrication, and erection of wood structures, and (3) specifications and design data.

While the title of the handbook refers to timber construction, in contrast to light-wood construction including framing, it apparently was not possible to draw a definite line between both fields. Heavy timber construction is fully covered. Light construction is discussed spottily. Hence, it might have been wise to give additional attention to the many light-wood construction systems which were developed during the past twenty years.

No consideration is given to such designs and construction practices which have been used more or less extensively for economic reasons in foreign countries, expecially in Europe. Thus it is evident to any observer familiar with European designs that the text is intended for the American practitioner and not for his European counterpart, although it should be most valuable to the Europeans interested in American timber design and construction.

As for any comprehensive book of this kind, the technicalities of publishing may have made it impossible to give consideration to recent developments in design and practice.

A new edition probably will devote considerable space to improved nails and nailing procedures as well as to newly developed fasteners, if it is desired that this handbook provide the essential information and know how obtained in these fields during the past few years. To be specific, the illustration used to demonstrate various types of available nails, for instance, was published more than twenty years ago, despite the fact that great strides have been made in nail design in this country since that time.

A chapter will have to be devoted to trussed rafters of various designs as developed and field tested in this country during the past few years. In this first edition, little, if any, consideration is given to nailed, nail-glued, toothed-plate jointed, inserted-plate jointed, and H-braced trussed rafters, all of which have proved to be particularly acceptable from the engineering, economic, and practical viewpoints under most field conditions encountered.

It is also hoped that a new edition of the handbook will include a comprehensive list of references for the benefit of those architects and engineers who require additional detailed information which cannot be included in a handbook of limited size.

In light of the foregoing, it is necessary for the teacher, who decides to choose this handbook as a textbook, to supplement the given information with additional know how in the field of light-wood construction.

To the student as well as to the practicing architect and engineer, this handbook can be of inestimable value, if they familiarize themselves with recent and current developments not covered in the handbook. E. G. Stern, USA

1445. Voinov, A. P., The carrying capacity of wooden beams, taking the time factor into account (in Russian), *Sb. Nauk Trudi Kharkovsk. Inst. inzh. kommun. str-va.* no. 5, 62–107, 1954; Rev. no. 599, *Ref. Zh. Mekh.* 1956.

Tests are described on the axial compression and elongation of pine, fir and oak wood along the fibers. Test diagrams are given which enable the author to make a diagram of the normal stresses during bending in the form of two trapezes, and to set up an approximate formula for the rupture moment of beams having various shapes of cross section, including box form. Introducing the reduction coefficient of 0.85 for the transition to the endurance strength from the value for a rapidly applied load, it is suggested that the formulas obtained should be used for calculating wooden beams for an endurance load according to the first limiting condition. The tests which were made with an invariable load duration up to 115 days, for bending 22 specimens with a section of 20×30 mm with a span of 100 cm of pine wood with a density of 0.58 g/cm^3 and a moisture of approximately 13% showed a difference between the test value of the rupture moment and the calculated value of less than 10%. Yu. M. Ivanov, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1446. Braley, S. A., Jr., Properties and applications of silicone rubber, ASME Semiann. Meet., Cleveland, Ohio, June 1956. Pap. 56-SA-53, 5 pp.

The properties of silicone rubber are discussed and compared to those of organic rubber, particularly at high and low temperatures. Silicone rubber is shown to be superior to organic rubber when the rubbers are subjected to temperatures above 250 F. The physiological inertness, dielectric properties, and resistance to various chemicals and oils also are discussed, as well as applications resulting from these properties. From author's summary

1447. Petrosyan, G. S., The flow and relaxation stresses of natural rubber (in Russian), *Sb. Nauk Trudi Erovansk. politeck. Inst.* no. 9, 265–270, 1955; Rev. no. 618, *Ref. Zh. Mekh.* 1956.

The results are described of experiments performed with a soft vulcanized natural rubber, in a range of conventional stresses of 12—60 kg/cm^2, and temperatures from 0 to + 60 C. The experiments were made with a special instrument, of which a somewhat incomprehensible description is given. The analysis of the results showed (1) The flow diagrams $\epsilon = f(\sigma, t, \theta)$ obtained at the given temperature, but with different stress values, are similar to each other. (2) Deformation of the flow at first rapidly increases, and then, after 1 to $1\frac{1}{2}$ hours, becomes stabilized. (3) Rubber is sensitive to temperature change (at + 60° the deformation in-

creases by 50%). (4) The relaxation diagrams of the stresses $\sigma = f(\epsilon, \theta, t)$ are also similar to one another. (5) A fall in the stresses occurs sharply in the first half hour, and later, the stresses in the speciman become stabilized. (6) With an increase in temperature, the fall of the stress in the specimen increases. A series of empirical formulas is given for calculation of the deformations and stresses. K. V. Zakharov, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1448. Gordon, J. E., Recent ideas in plastics for aircraft structures, *J. roy. aero. Soc.* **60,** 547, 476–481, July 1956.

Strong plastics consist of two-phase arrangements of pairs of brittle solids which in combination may be very tough. Improvement now depends upon an understanding of brittle solid theory. The strength of brittle solids is generally very low but may occasionally approach the very high theoretical values. This is due to the high inherent strength being generally marred by tiny defects. When these defects are removed or contained, high strength may be achieved. The various mechanisms by which this may be done are exemplified in mica, common salt, glass, metal whiskers, and so on. The relevance of these substances and mechanisms to the manufacture of plastics is discussed.

From author's summary

1449. Scholten, R. A., Ceramic magnets, *Prod. Engng.* **27,** 13, 143–148, Dec. 1956.

Plasticity, Forming and Cutting

1450. Eder, E., Lamellae formation and the region of plastic flow in cutting (in German), *Werkstattstech. Maschinenb.* **46,** 10, 505–509, Oct. 1956.

Author verifies experimentally that the lamellae formation, observed on the back of chips, is the result of chatter. Equations are derived for the stress distribution in the chip and also for the principal stresses, based on ideal plasticity.

D. Kececioglu, USA

1451. Boulger, F. W., Hartner, H. E., Lankford, W. T., and Garvey, T. M., Force relationships in the machining of low-carbon steels of different sulphur contents, ASME Semiann. Meet., Cleveland, Ohio, June 1956. Pap. 56-SA-21, 10 pp.

The force relationships obtained in the machining of a series of low-carbon open-hearth steels containing various amounts of sulphur from 0.025 to 0.250% were investigated in a constant-pressure lathe and in a conventional lathe. A wire-resistance strain-gage dynamometer was used to measure the forces acting on a high-speed tool for various cutting conditions. In the constant-pressure test, sulphur additions increased the feed obtained with a given thrust load. The addition of sulphur reduced the forces acting on the tool for equivalent feeds in both test lathes. Theoretical calculations disclosed that the effectiveness of increased sulphur contents results from decreased friction between the chip and the tool and from an accompanying reduction in strain during chip formation. The decrease in friction and strain reduced the work required for removal of a unit volume of metal during machining. Shear stress was not a direct function of sulphur content, but generally decreased with feed. Results of conventional lathe tests generally corroborated those obtained in the constant-pressure lathe. From authors' summary

1452. Shaffer, B. W., Analysis of chip formation in the turning operation, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Eng 1955, 499–504.

Continuous chips may be formed, during machining, by a simple shearing process between the uncut material and newly formed chip. It is shown that for the turning operation this shearing action takes place along a circular shear line. Equations are derived which describe the radius and the position of the shear line relative to the cutting tool.

Equations are also derived which express the machining force and the chip thickness ratio in terms of the rake angle of the tool, coefficient of friction, the appropriate yield stress of the workpiece, and the radius of the workpiece.

From author's summary

1453. Boston, O. W., and Gilbert, W. W., Forces and power required to turn aluminum and seven alloys, ASME Semiann. Meet., Cleveland, O., June 1956. Pap. 56-SA-14, 6 pp.

1454. Galloway, D. F., Some experiments on the influence of various factors on drill performance, ASME Semiann. Meet., Cleveland, O., June 1956. Pap. 56-SA-18, 19 pp. + 7 appendixes + 45 tables + 57 figs.

These experiments are part of a series of investigations to obtain basic data needed for improving drilling techniques in a number of engineering factories. The main criteria of drill performance, and some of the principal factors which influence performance are discussed. Special attention is given to drill shape, and particularly to those elements, such as relief angle, point angle, relative lip height, etc., which can be controlled by the drill user. The theory of self-regenerative vibration in drilling is discussed, and theories are developed to explain inaccuracies in hole size and alignment. The paper includes test results which tend to support these theories. Reference is made to those considerations of drill geometry and specification which entered into the investigations. The influence of the drilling machine on drill performance was discussed in a previous paper by the author.

From author's summary

1455. Fukui, S., Yoshida, K., Abe, K., and Hotta, Y., Deep drawing of rectangular boxes (in Japanese), *J. Japan Soc. mech. Engrs.* **59,** 455, 898–903, Dec. 1956.

As the continuation of earlier papers of S. Fukui and his coworkers ["On deep drawing of square boxes," *Rep. Inst. Sci. Technol. Tokyo* **5,** 3–4, 121–133, Mar.-Apr. 1951, and **8,** 1, 13-22, Jan. 1954], blank development, maximum drawing force, and forming limits in cupping rectangular box-shaped parts are experimentally studied. An empirical formula estimating maximum drawing force from the known mechanical properties of materials, blank dimensions, and die geometry is presented. Forming limits are discussed in relation to die geometry. Materials used in the experiment are aluminum, copper, and 70/30 brass in annealed state.

Y. Yamada, Japan

1456. Romadin, V. P., Kisel'gof, M. L., and Sokolov, N. V., Calculating the capacity of shaft-type impact mills (in Russian), *Teploener getika* **3,** 3, 58–61, Mar. 1956.

1457. Harrison, P. W., Optical instrument for measuring camber on large rolls, *Engineer, Lond.* **202,** 5250, 327–329, Sept. 1956.

An instrument has been designed and constructed at the National Physical Laboratory to measure the camber of the top surface of rolls, such as those used in paper and metal sheet mills (which may be as much as 25ft long and up to 15ft in diameter), to an accuracy of ± 0.0005 in. under optimum conditions. It has been designed to operate in a restricted space so that static tests can be made on the roll while in the machine. The instrument consists of three components: a light source with a single horizontal slit, a double slit, and a micrometer-controlled graticule of novel design. Young's interference fringes produced by suitably positioning the slits provide an optical datum plane to which the roll surface is referred. The slits have been made by a new method, and the double slit is so mounted that the instrument can accommodate considerable positive or negative camber on the roll to be measured.

From author's summary

Hydraulics; Cavitation; Transport

(See also Rev. 1648)

1458. Lance, G. N., and Deland, E. C., The shape of the nappe of a thin waterfall, *Quart. J. Mech. appl. Math.* **9,** 4, 394–399, Dec. 1956.

A nonlinear differential equation for the two-dimensional title problem is derived and solved with the aid of a differential analyzer. Allowance is made for surface tension and a pressure difference across the jet, as well as for gravity. The shape of the nappe is shown to be extremely sensitive to air pressure. No experimental results are provided to check the accuracy of the theory.

L. C. Woods, Australia

1459. Streeter, V. L., A flow controller for open or closed conduits, *Proc. Amer. Soc. civ. Engrs.* **82,** HY 4 (*J. Hydr. Div.*), Pap. 1037, 28 pp., Aug. 1956.

Problem of maintaining, automatically, a constant discharge in a conduit, for a range of heads, but with a continuously variable choice of discharge, is treated. A control—consisting of a disk moving within a profiled throat, and a nonlinear resistance to support the disk against the pressure drop—is analyzed, and the equation of the throat profile and the law of variation of the resistance are found which give an exact theoretical solution of the problem. Several methods of obtaining the required resistance are suggested and discussed in detail. The device can also be used as a flow meter by reversing the throat section and measuring the head across the disk. Tests on a model are described and results presented for both the flow control and the flow meter.

L. Landweber, USA

1460. Kartvelishvili, N. A., Mathematical representation and calculation methods in river flow regulation (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 126–136, Jan. 1956.

Author compares statistical and genetic methods and their significance in hydrology. Statistical method alone can be applied for a basin at stationary conditions; it will fail when runoff is essentially changed by reservoirs. Author opposes usual selection of few typical years for detailed investigation. Instead, he suggests construction of an idealized hydrograph, where discharge of desired probability is computed for every day through a year. Integration is performed for solution of any problem connected with runoff regulation within limits of an assigned probability.

S. Kolupaila, USA

1461. Aver'ianov, S. F., Hydraulic design of channels of curvilinear cross section (in Russian), *Izv. Akad. Nauk SSSR, Otd. tekh. Nauk* no. 1, 54–58, Jan. 1956.

Parabolas of higher power and ellipse are applied to cross sections of channels excavated by dredging. The size of channel is computed for required area and side slope at certain levels, mostly at the surface. Formulas are derived for determination of wetted perimeter; a table of these values for different powers is presented. Principle of the best hydraulic section is adopted, with a minimum length of wetted perimeter. This is an extension of a previous article by same author (1948).

S. Kolupaila, USA

1462. Ibad-Zade, Yu. A., The forming of the cross section of a natural course (in Russian), *Trudi Energ. Inst. Akad. Sci.* no. 12, 173–193, 1954; Rev. no. 201, *Ref. Zh. Mekh.* 1956.

In more detailed form, the recently published results of the author are given [*Ref. Zh. Mekh.* 1954, Rev. 4073] relating to the geometrical characteristics of courses (area, wetted perimeter, hydraulic radius, width of upper portion, and optimum hydraulic section) the form of which is similar to that of an elastic cord loaded by the force of hydrostatic pressure. Certain comparative calculations are given.

G. K. Mikhailov, USSR

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Translation, courtesy Ministry of Supply, England

1463. Kreith, F., and Eisenstadt, R., Pressure drop and flow characteristics of short capillary tubes at low Reynolds numbers, ASME Semiann. Meet., Cleveland, O., June 1956. Pap. 56-SA-15, 5 pp.

The pressure drop and flow characteristics of short capillary tubes have been investigated experimentally for length-to-diameter ratios varying from 0.45 to 18 at diameter Reynolds numbers ranging from 8 to 1500. In the range of the dimensionless modulus $(L\mu)/(VD^2\rho)$ from 4×10^{-3} to 3 to 10^{-1}, the experimental data agree within 15% with a mathematical theory by Langhaar. At a value of $(L\mu)/(VD^2\rho)$ of about 0.3, the experimental data approach the Poisseuille laminar-flow theory. For very short tubes ($L/D <$ 0.5), the experimental results deviate from Langhaar's theory at values of $L\mu/VD^2\rho$ less than 4×10^{-3}; and at $L\mu/VD^2\rho$ equal to 5×10^{-4}, the pressure drop is twice as large as that predicted by Langhaar's theory. The experimental results for tubes having very short aspect ratios are in agreement with data obtained by Zucrow with short square-edged jets. It was found that the flow rate $\dot{Q}$ through a short capillary tube can be related empirically to the over-all pressure drop Δ_p raised to a power N. The exponent N is a function of the length-to-diameter ratio L/D varying from 0.5 at L/D equal to 0.45 to 0.91 at L/D of 18. The trend of the curve suggests an asymptotic approach to unity, the exponent for Poisseuille-type flow. The results of this study have application to: (*a*) Simulating flow through screens, doors, cracks, and fissures in small-scale model testing of buildings in atmospheric wind tunnels; (*b*) automatic control devices where capillary tubes are used as hydraulic resistances in a larger line and in nozzle-flapper combinations; (*c*) heat pumps and air-conditioning equipment where short capillary tubes are used as two-way control valves; (*d*) flow through compact heat exchangers and porous materials.

From authors' summary

1464. Schnell, E., Slippage of water over nonwettable surfaces, *J. appl. Phys.* **27,** 10, 1149–1152, Oct. 1956.

When water flows over glass which has been treated with the vapor of dimethyldichlorosilane and thus made water repellent, slipping on the boundary between the solid surface and the water takes place. This is shown in capillary tubes of various diameters. The amount of slipping is small, but measurable. It disappears or becomes extremely small in case of turbulent flow.

From author's summary

1465. Kohler, W. H., Development of hydraulic operation for gates and valves, ASME Fall Meet., Denver, Colo., Sept. 1956. Pap. 56-F-8, 7 pp.

Paper contains a brief review of the application of hydraulic operation and control of gate hoists and valves at the Bureau of Reclamation. It summarizes the growth in the use of hydraulic operation during the past 25 years and describes new applications at Hoover, Grand Coulee, Shasta, and Palisades Dams.

From author's summary

1466. Kovacs, G., Seepage under dams (in Hungarian), *J. Hydrology* **36,** 3, 171–185, June 1956.

Electric analogy method was applied to dam models on pervious soil layer of definite depth b with aprons of variable length $2b$ and diaphragms of different height l, representing the sheet pile cut-off walls. The formula was derived $q/q_0 = 1 - a/(b/2b + 1)^n$, where q is the rate of reduced seepage, q_0 the same for indefinite layer of pervious soil without any diaphragms, b the length of an upstream apron, a and n are constants, functions of the ratio l/b; usually a varies between 1 and 0.90 and n between $\frac{1}{3}$ and $\frac{2}{3}$.

S. Kolupaila, USA

1467. Brownell, W. F., A 36-inch variable pressure water tunnel, *David W. Taylor Mod. Basin Rep.* 1052, 23 pp. + 33 figs., June 1956.

1468. Kindsvater, C. E., and Randolph, R. R., Jr., Hydraulic model studies of Martin Dam draft tubes, *Trans. Amer. Soc. civ. Engrs.* **120,** 1399–1419, 1955.

1469. Tachmindji, A. J., Comparison of face cavitation on model and full scale propellers, *David W. Taylor Mod. Basin Transl. Rep.* no. 1058, 7 pp. + 8 figs., July 1956.

An attempt has been made to understand the phenomenon of model and full-scale cavitation correlation by investigating the simple case of a propeller operating in practically uniform flow. The results indicate that face cavitation depends on a number of parameters which, in general, are satisfied in the mean. It appears, however, that second-order effects in those parameters may produce significant changes in the cavitation pattern. What is generally termed scale effect may, to a certain extent, result from our failure to satisfy second-order effects.

From authors' summary

1470. Mark, M., Collapsing pressures of non-symmetrical bodies, *Prod. Engng.* **27,** 10, 165–166, Oct. 1956.

Incompressible Flow: Laminar; Viscous

(See also Revs. 1412, 1531, 1539, 1544, 1607, 1608, 1654)

1471. Keim, S. R., Fluid resistance to cylinders in accelerated motion, *Proc. Amer. Soc. civ. Engrs.* **82,** HY 6 (*J. Hydr. Div.*), Pap. 1113, 14 pp., Dec. 1956.

Cylinders restrained against lateral motion were accelerated by the application of a constant force. For series of eight tests, coefficient of drag is presented as function of $(dv/dt)D/V^2$, in which v and D are velocity and diameter of cylinder.

Lack of interpretation of results illustrates, in reviewer's opinion, the severely limited value of empirical testing of occurrences which are not yet well understood. J. S. McNown, USA

1472. Taneda, E., Experimental investigation of the wake behind a sphere at low Reynolds numbers, *J. phys. Soc. Japan* **11,** 10, 1104–1108, Oct. 1956.

Experiments were made by moving steel spheres through water in a tank. Photographs of streamlines were taken by a camera moving with the sphere, using aluminum dust in the water. For Reynolds numbers between about 30 and 130, length of vortex ring in direction of stream varies linearly with log R. Hence, by extrapolating to zero length, author finds that vortex ring begins to form at $R = 24$. For $130 < R < 200$, long-period pulsations occur at rear of vortex ring, but flow downstream is still laminar. Author notes contrast with circular cylinder, where length of vortex pair in direction of stream varies linearly with R, not log R.

W. A. Mair, England

1473. Harada, M., and Kinoshita, S., Research on the secondary losses. 1. On the secondary vortex in cascades (in Japanese), *J. Mech. Lab. Tokyo* **10,** 5, 127–183, Sept. 1956.

The secondary and trailing vortexes of the cascade due to non-uniformity in the upstream velocity have been analyzed by J. H. Preston for two-dimensional impulse blading [AMR **8,** Rev. 3441]. Some extensions of his theory to two-dimensional accelerating and retarding cascades are developed with some simple assumptions. The values of the circulation of the secondary and the trailing vortexes are calculated for small turning angle. The ratio of the circulation of these two vortexes is mostly dependent on the outlet angle of the flow through cascade. Although the approximations will hold only for small turning angles, and high accuracy of the numerical results of the present theory will not be expected for a wide range, the relation of these two vortexes is explained clearly.

M. Yamanouchi, Japan

1474. Nielsen, J. N., and Pitts, W. C., General theory of wave-drag reduction for combinations employing quasi-cylindrical bodies, with an application to sweptwing and body combinations, *NACA TN* 3722, 79 pp., Sept. 1956.

The wing-body interference theory of Nielsen and Pitts [AMR 6, Rev. 565], where one deals with local pressures, is used to find body distortions required to reduce the drag of a given wing-body combination where the wing is prescribed in advance. Here the body shape must fulfill the quasi-cylindrical condition, and the wing must have no local loading or have supersonic leading and trailing edges. In wings of the latter case where local lift is involved, the body distortions are limited upstream to approximately the wing-trailing-edge juncture. An integral equation must be solved to obtain the body distortions required for minimum drag. Approximate methods are derived for wings of several limiting planforms. Several illustrative examples are included.

H. Yoshihara, USA

1475. Wadhwa, Y. D., Slow viscous drag, *Bull. Calcutta math. Soc.* **48,** 1, 45–46, Mar. 1956.

An analysis is given for the drag of an infinite cylinder whose cross section is a lemniscate of Bernouilli. The solution is based upon the superposition of two motions. The drag is proportional to the dynamic viscosity and the upstream velocity.

R. C. Binder, USA

1476. Rusanov, B. V., Slow unsteady flow about a circular cylinder by a viscous fluid (in Russian), *Vestnik Leningr. Univ.* no. 2, 81–106, 1955; Rev. no. 244, *Ref. Zh. Mekh.* 1956.

An examination is made of the problem of an unsteady flow about an infinite circular cylinder, by a slow two-dimensional flow of a viscous incompressible fluid. The velocity components $u(x, y, t)$ and $v(x, y, t)$ are sought in the following form

$$u = u^{\mathrm{I}} - u^{\mathrm{II}} \qquad v = v^{\mathrm{I}} - v^{\mathrm{II}}$$

where

$$u^{\mathrm{I}} = \frac{1}{4\pi t} \int_D\int u^0(\xi, \eta) \exp\left(-\frac{(x-\xi)^2 + (y-\eta)^2}{4t}\right) d\xi d\eta$$

$$v^{\mathrm{I}} = \frac{1}{4\pi t} \int_D\int v^0(\xi, \eta) \exp\left(-\frac{(x-\xi)^2 + (y-\eta)^2}{4t}\right) d\xi d\eta$$

where D is the region, external with regard to the circle $r = 1$ and u^0 and v^0 are the given components of the nondimensional velocity w^0 at the initial instant of time.

In finding the functions u^{II} and v^{II} and also the pressure p, operational calculation is used. The expressions for u^{II} and v^{II} and p assume the form

$$u^{\mathrm{II}} = \frac{u^0(r, t)}{2} + \sum_{n=1}^{\infty} u_n(r, t) \cos n\theta$$

$$v^{\mathrm{II}} = \sum_{n=1}^{\infty} v_n(r, t) \sin n\theta$$

$$p = \sum_{n=1}^{\infty} \frac{a_n(t)}{r^n} \cos n\theta$$

$$r = \sqrt{x^2 + y^2} \qquad \theta = \tan^{-1}(y/x)$$

and the functions u_n, v_n and a_n are determined from rather laborious formulas, which are indicated in the paper. Author carefully investigates the solutions obtained, and comes to the conclusion that it is impossible to have steady conditions of flow about a cylinder by a viscous fluid, i.e., the Stokes paradox. The problem is examined of slow unsteady motion of a cylinder in a viscous fluid. As indicated in the paper, the latter problem, in various variations, was investigated earlier by many authors. Author solves this problem by assuming an arbitrary law of motion of the cylinder, and as-

suming that, at the initial instant, the fluid is at rest. Formulas were obtained for velocities and pressures, and the problem of the drag force was examined. V. A. Vasil'ev, USSR

Courtesy of Referativnyi Zhurnal
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1477. Nuzhin, S. G., Design of a wing profile according to the chord diagram of pressure determination (in Russian), *Trudi Kazansk. Aviat. Inst.* no. 28, 7–27, 1953; Rev. no. 111, *Ref. Zh. Mekh.* 1956.

A method is given for designing a wing profile in a flow of incompressible fluid according to the chord diagram of pressure determination, based on the conformal representation of the external part of the profile to the external part of a circle. The coordinates of the profile are expressed coefficients of the Loren series for complex velocity and are determined by the successive approximation method. As initial correspondence between the points of the chord of the profile and the points of the perimeter, the correspondence is taken which occurs for a flat plate. The Loren series for the complex velocity is limited by 3 terms. A numerical example is given for plotting the RAF 34-8 profile according to pressure determination. Ya. M. Kotlyar, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1478. Okamoto, T., and Mikami, F., Incompressible flow around a rectangular protuberance or groove on a plane boundary, *Bull. Tokyo Inst. Tech.* (*B*) no. 1, 7–15, 1956.

Analytic solutions are deduced in terms of elliptic integrals from which flow patterns and pressure distributions surrounding rectangular projections or cutouts are easily determined. Application of the Schwarz-Christoffel transformation permits a complex potential specification for the resulting rectilinear flow and a subsequent correspondence of velocity components and Cartesian coordinates. Examples are provided for both square projections and cutouts, with streamlines and pressures depicted graphically. Of note is the extension of the problem for flow against normal plates to the case of finite thickness. The incompressible flow through wind-tunnel contractions may also be approximated, at least for small area changes. J. R. Baron, USA

1479. Guilloton, R., Induced curvature of thin wings (in French), *Bull. Assn. tech. marit. aêro.* no. 54, 263–291, 1955.

Author treats the theory of lifting surface, introducing a new term "induced curvature," which takes into account the effects of free vortexes at various points along a section of wing. Assuming elementary circulation as a Fourier series with 6 terms, formulas and numerical tables necessary to calculate induced velocity are given. A comparison with experimental data shows good agreement, but it must be noticed that airfoils such as author's example give smaller lift than theoretical one, owing to the deflection of training edge. M. Kataoka, Japan

1480. Guilloton, R., Application of induced curvature for the calculation of marine propellers (in French), *Bull. Assn. tech. marit. aêro.* no. 54, 293–335, 1955.

Results obtained by the author in a previous report [see preceding review] are applied to marine propeller with wide blades. Numerical calculation and its comparison with experiments are given. It is remarkable that a good agreement of this theory with experiments is obtained without the consideration of blade interference. M. Kataoka, Japan

1481. Benson, R. S., One-dimensional transient flow in a pipe with two gases, *Engineer, Lond.* **202,** 5260, 687–691, Nov. 1956.

Unsteady flow in a pipe containing a stratified column of two or more gases at different temperatures is of interest to engineers in connection with either the exhaust pipes of internal combustion engines or the "Comprex" unit in a gas turbine. In this article, a theoretical study is made of the unsteady flow process in a simple system of two gases with different molecular weights and ratio of specific heats. The complex equations are linearized by suitable approximations and a solution is produced analogous to the simple case of a temperature discontinuity, which may be solved by the method of characteristics. A detailed example is given. Arising from the linearized theory, parameters are developed for "dynamic" similarity in transient flow systems of two or more gases, and charts are produced from which a rapid computation of the magnitude of the reflected and transmitted pressure waves at the discontinuity may be made. Finally it is shown that, in an internal-combustion-engine exhaust system, the effect of the difference in the ratio of specific heats of the exhaust gas and cold air may influence the pressure-wave amplitude by about 5% and the wave velocity by about 30%. From author's summary

1482. Tsukker, M. S., Vortical flow moving in a space filled with the same fluid (in Russian), *Prikl. Mat. Mekh.* **19,** 4, 500–503, July/Aug. 1955.

Author writes the Navier-Stokes equations in spherical coordinates and solves them for a type of flow somewhat resembling a vortex ring with additional swirl about the axis of the ring. A quite general, and simple, solution is produced, relating the velocity components and pressures to a Reynolds number. The method of solution may be of interest to fluid dynamicists; the flow configuration, while undoubtedly of interest also, is not quite what one would expect in nature, having infinite velocities near the center. R. A. Burton, USA

1483. Wada, I., Aerodynamic research on accelerating cascade. V, Cascade test of nozzle blades (in Japanese), *J. Mech. Lab. Tokyo* **9,** 5, 207–212, Sept. 1955.

Experimental investigations on turbine-nozzle cascade at low speed are presented. Parabolic camber lines and base profile of NACA 0009 are used. The camber angles of the blades are 65°, 70°, and 75°, and the pitch-chord ratios are 0.52, 0.8, and 1.0.

The results are as follows: (1) Although air outlet angle obeys the $\cos^{-1}(o/s)$ rule at low pitch-chord ratio, the rule is not valid for higher values; (2) the values of the total head loss coefficient are about 0.02 and 0.01 for low and high pitch-chord ratio, respectively; (3) the most effective pitch-chord ratio seems to be approximately 0.8. M. Yamanouchi, Japan

1484. Wada, I., Aerodynamic research on accelerating cascade. VI, Cascade test of nozzle blades (in Japanese), *J. Mech. Lab. Tokyo* **10,** 5, 184–189, Sept. 1956.

Continuing from the preceding report [see preceding review], experimental investigations on turbine-nozzle cascade at low speed are presented. Base profile of NACA 0009 is used. The camber angles of the blades are 40° and 55°, and the pitch-chord ratios are 0.52, 0.8, and 1.0. Parabolic and circular camber lines are used for the camber angle of 40° and 55°, respectively. It is concluded that, at low speed, the performance of the blades of circular arc camber seems to be inferior to that of the others.
M. Yamanouchi, Japan

1485. Kramer, J. J., Analysis of incompressible, nonviscous blade-to-blade flow in rotating blade rows, ASME Semiann. Meet., Cleveland, O., June 1956. Pap. 56-SA-66, 27 pp. + 12 figs.

Theory is developed for steady potential flow of an incompressible, nonviscous fluid in a centrifugal impeller of chosen geometry, with or without splitter vanes between the blades. Streamline sheet is taken along mean blade height and with thickness equal to passage width. Assuming Kutta trailing-edge condition, relaxation solutions are found for the stream function equation. Numerical results are given for one impeller at four flow conditions, yielding streamlines and constant velocity contours in radial-tangential plane. Details of leading edge flow are obtained by use of finer

mesh solution. Results show large eddy at driving face of blade at condition near surge. W. G. Cornell, USA

1486. Morgan, A. J. A., On a class of laminar viscous flows within one or two bounding cones, *Aero. Quart.* **7,** 3, 225–239, Aug. 1956.

Author investigates the laminar viscous flows bounded by either right inner and outer conical surfaces with a common apex or a single cone. He finds exact similarity solutions of the Navier-Stokes equations which reduce the partial differential equations to a single nonlinear ordinary equation (a Riccati equation) for the tangential velocity component. This equation can be solved by hypergeometric functions. Admissible boundary conditions are suction or injection velocities at the cone surfaces inversely proportional to the distance from the origin. For impermeable surfaces with no-slip conditions, it is proved that the liquid must be quiescent for this type of solutions. Thus this approach cannot be used to describe the flows within conical diffusors.

K. Pohlhausen, USA

1487. Hak, J., Channel with manifolds, a contribution to the ventilation problem of a turbogenerator (in German), *Electtrotech. u. Maschinenb.* **73,** 15/16, 373–379, Aug. 1956.

Author attacks the problem under simplifying conditions: (1) All manifolds and all main channel segments are equal; (2) exit pressure of all manifolds is the same; (3) deviation resistance at the entrance of any manifold contains only terms with square of main flow rate and square of manifold flow rate, but not their product nor other function. (Reviewer calls "deviation resistance" what author calls "part of deviation resistance due to main flow." The other parts are included by author (and reviewer) in the proper manifold resistance and in the main channel resistance.)

Two cases are studied: (1) the whole system is rough (square skin-friction law); (2) smooth main channel (Blasius' law) with rough manifolds (this case is not concluded in this issue).

For case (1), two methods are employed: (a) step-by-step calculation from manifold to manifold; (b) analytical integration, supposing continuous flow deviation instead of discrete manifolds.

The (b) integration, mathematically easy but practically complicated, is elaborated by author in a very elegant manner to obtain dimensionless graphs for direct use. Interesting details of the deviated flow distribution are obtained.

For the (a) step-by-step calculation, author supposes that the deviation resistance (see reviewer's comment in paragraph 1) depends *only* on the flow *beneath* the manifold entrance. Reviewer believes this may be the cause why, in some cases, fluctuating solutions for deviated flow distribution are obtained (and imaginary solutions, too); perhaps with deviation resistance depending on flow *ahead* of deviation, or from *both*, all curves would be smooth. But author emphasizes a complete lack of experimental data for this and other details of the phenomenon; therefore reviewer believes any conclusion about it is premature.

For case (2), smooth main channel, the step-by-step method was employed; deviated flow distribution results similar to that of rough main channel. Paper is not concluded in this issue. Also author mentions a bibliography, but it is not included in this section of paper.

Reviewer believes the problem is of acute interest for many applications and worth further experimental and theoretical investigation. M. Krivoshein, Argentina

1488. Estoque, M. A., A prediction model for cyclone development integrated by Fjörtoft's method, *J. Meteor.* **13,** 2, 195–206, Apr. 1956.

1489. Kadymova, K. S., Investigation of the work of gas separators (in Russian), *Trudi Azerb. N-i Inst. po. dobyche nefti* no. 1, 113–143, 1954; Rev. no. 288, *Ref. Zh. Mekh.* 1956.

The theory of gas separators is explained, taking into consideration the interactions of the gas bubbles. A description is given of the laboratory apparatus for testing various designs of gas separators, and generalized results of the experiments are given. On the basis of the theoretical and experimental investigation, the conclusion is drawn that preference should be given to mono- and multi-unit separators as being simpler in design and operation. Various types of impacting devices (plates, layers of gravel, etc.) do not produce appreciable differences in the separation coefficient and, at the same time, they create considerable resistance to the flow of the gas or fluid. The design of an input nozzle does not influence the separation coefficient either. In designing helical separators, angles of deflection of not more than 40–50° should be selected. S. M. Il'yashenko, USSR

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1490. Dubov, V. S., The propagation of a free twisted jet in an inundated space (in Russian), *Trudi Leningr. Politechn. Inst.* no. 176, 137–145, 1955; Rev. no. 277, *Ref. Zh. Mekh.* 1956.

Developing the method of L. G. Loitsianski, a solution is given of the distribution of a free laminar twisted jet in an inundated space to the third approximation. Using the hypothesis of the constancy of the coefficient of "turbulent viscosity" in the cross section of the jet, author generalizes the solution obtained for laminar flow in the case of a turbulent twisted jet. The results of calculation of the parameters of the turbulent twisted jet (to the third approximation) agree with experiments for a closer distance from the source of the jet, better than the results of the first two approximations. G. L. Grodzovskii, USSR

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1491. Craya, A., and Curtet, R., On the development of a jet in a confined space (in French), *C. R. Acad. Sci. Paris* **241,** 8, 621–622, Aug. 1955.

The integral momentum and continuity equations are set up in the flow direction for co-axial, two-dimensional, incompressible jets flowing in a duct. Paper assumes similar velocity and momentum flux profiles in the whole mixing region, which permits evaluation of the flow field if an additional experimental jet spread coefficient is introduced.

Value of paper is in its concise, if overcondensed, mathematical development, but the general approach does not differ significantly from the work reported by other investigators. Good agreement with experimental results was reported by the authors in AMR **9,** Rev. 3972 and AMR **10,** Rev. 1492. Validity of the theory for use in ejector applications with pressure gradients still awaits experimental verification. F. Landis, USA

1492. Curtet, R., Contribution to the study of jets (in French), *C. R. Acad. Sci. Paris* **241,** 21, 1447–1450, Nov. 1955.

Paper is one of a series of short notes on jet mixing of incompressible jets, presented by the author in the Comptes Rendus. Experimental data on the jet mixing of two co-axial, two dimensional jets are shown and compared to the experimental results obtained by other authors. Data presented cover profile similarity in the established mixing region, a jet spread coefficient σ, the jet spread boundary, and the jet centerline velocity, all normalized and given as functions of primary and secondary mass flow rates.

Results computed by the semi-empirical integral methods of an earlier paper, using the assumption of a constant mean spreading coefficient, agree favorably with the experimental data shown in this note. F. Landis, USA

1493. Okamoto, T., and Mikami, F., Flow around orifice utilized for injection or suction of fluid, *Bull. Tokyo Inst. Tech.* (B) no. 1, 17–24, 1956.

The two-dimensional potential flow in the neighborhood of a rectangular cutout with a source on its bottom face is analyzed. Two

problems are treated: the isolated source (or sink) at the center of the cutout, and the source (or sink) distributed along the entire bottom face. In the latter problem, the source strength is assumed uniform in the transformed plane, resulting in a nearly parabolic source-strength distribution in the physical plane. The source strength is chosen to give a stagnation point at the appropriate upper corner of the cutout, thus forcing the boundary between the main flow and the jet flow to be a streamline common to both flows, with continuous velocity variation across it. The authors, unfortunately, did not include the solution of the problem in which jet separates from the downstream edge of the cutout.

W. Daskin, USA

1494. Gray, F. A., and Robertson, A. D., The investigation of fluid flow problems by model techniques, *J. Inst. Fuel* **29,** 189, 428–436, Oct. 1956.

Paper describes laboratory established by United Steel Companies (England) for research in industrial fluid-flow problems. Nature of most tests requires flow of air at low static pressure through scale model rather than around it, as in most previous fluid-flow investigations. Problems are quite general, but have been concerned mostly with flow in furnaces, flues, combustion chambers, etc. Methods of designing models, setting up equipment, making tests, and interpreting results are given. Geometric similarity and constancy of Reynolds number are taken as conditions for dynamic similarity, with no allowance for compressibility effects except for certain corrections when wide temperature variations occur. Treatment and results of several actual problems are given by way of illustration.

Paper should be of value to persons concerned with setting up a similar laboratory or in making tests of this kind.

C. W. Smith, USA

1495. Erickson, R. P., Motion of suspension mechanisms with Coulomb damping, Proc. second Midwestern Conf. solid Mech., Purdue Univ., Sept. 1955, 214–228.

By the use of an analog computer the motion of a single-degree-of-freedom suspension mechanism is studied. The equation of motion of the system is a second-order nonlinear differential equation. The nonlinear term takes into account the effect of dry friction. Computer solutions in the form of curves are obtained for sinusoidal and square wave forcing terms. The solutions are compared with those of a similar device that contains viscous instead of dry friction.

The results of this paper supplement analytical solutions obtained by J. P. Den Hartog and others. L. Pipes, USA

1496. Khaskind, M. D., Unsteady gliding over a perturbed surface of a heavy fluid (in Russian), *Prikl. Mat. Mekh.* **19,** 3, 331–342, 1955.

Compressible Flow, Gas Dynamics

(See also Revs. 1545, 1546, 1547, 1571, 1576)

1497. Maki, R. L., and Hunton, L. W., An investigation at subsonic speeds of several modifications to the leading-edge region of the NACA 64A010 airfoil section designed to increase maximum lift, *NACA TN* 3871, 50 pp., Dec. 1956.

Three modifications to the leading-edge region of the NACA 64A010 airfoil section were designed and tested two-dimensionally at both low and high subsonic speeds. The modifications increased the low-speed maximum lift coefficient of the symmetrical reference section by as much as 0.58, largely by increasing the angle of attack at which stall occurred. A single-criterion design procedure for estimating the incremental maximum lift due to an arbitrary modification, based on control of the theoretical pressure peak, was unsatisfactory.

Tests at high speeds showed that the maximum-lift increments provided by the leading-edge changes were reduced by compressibility effects, and vanished at about a Mach number of 0.65. The high-speed drag characteristics of a modified section with 1.1%-chord nose radius and camber over the forward 15% chord were somewhat improved over those of the NACA 64A010 section.

From authors' summary

1498. Roy, M., Theory of jet flap airfoils (in French), *C. R. Acad. Sci. Paris* **242,** 26, 3017–3021, June 1956.

Author considers inviscid subsonic plane flow and expresses lift, drag, and pitching moment by circulation Γ_∞ at infinity. Γ_∞ is sum of the integrated jet sheet vorticity Γ' and the circulation Γ around the wing contour, Γ' being simply related to the jet exit angle and momentum. Γ is assumed to be made up of three parts; one due to angle of attack with respect to uniform flow, one due to apparent change of zero-lift direction caused by jet-induced flow at rear end of profile, and, finally, one due to upwash at profile inducted by jet sheet vorticity. By making plausible assumptions for the latter two parts, partially founded on results from small-perturbation theory, a simple formula is obtained for the lift coefficient as influenced by angle of attack, jet angle, and jet momentum coefficient. Approximations include the substitution of a concentrated vortex for the jet sheet vorticity.

Reviewer believes approach proposed by author might prove useful when extending Prandtl lifting-line theory to jet flap wings.

S. B. Berndt, Sweden

1499. Harder, K. C., and Klunker, E. B., On slender-body theory and the area rule at transonic speeds, *NACA TN* 3815, 14 pp., Nov. 1956.

The basic ideas of the slender-body approximation have been applied to the nonlinear transonic-flow equation for the velocity potential in order to obtain some of the essential features of slender-body theory at transonic speeds. The results of the investigation are presented from a unified point of view which demonstrates the similarity of slender-body solutions in the various Mach number ranges. The primary difference between the results in the different flow regimes is represented by a certain function which is dependent upon the body area distribution and the stream Mach number. The transonic area rule and some conditions concerning its validity follow from the analysis.

From authors' summary by M. H. Bertram, USA

1500. Heaslet, M. A., and Fuller, F. B., Particular solutions for flows at Mach number 1, *NACA TN* 3868, 32 pp., Nov. 1956.

The small-disturbance potential at unit stream Mach number is the solution of a nonlinear partial differential equation. Following Guderley and Yoshihara [AMR **4,** Rev. 1664], authors introduce new independent and dependent variables and reduce the partial differential equation to an ordinary one, for which families of either pure supersonic or pure subsonic two-dimensional or rotationally symmetric solutions can be obtained. Explicit examples are given: (1) Flow starts as a supersonic flow along a plane wall, changes continually to a flow along a slightly curved wall, and passes through a shock into a subsonic flow along a slightly curved wall which tends to become plane. (2) The corresponding flow with axial symmetry.

It should be mentioned that, in the two-dimensional case, the transition from supersonic to subsonic flow is only possible by "strong shock"; in the case with axial symmetry the shock belongs to the weak family. I. Flugge-Lotz, USA

1501. Takano, A., Transonic flow past the two-dimensional wedge with detached shock wave Part I, *J. Japan Soc. Aero. Engng.* **4,** 25–26, 38–44, Feb./Mar. 1956.

The solution to the transonic hodograph equation for the stream function, already obtained by Vincenti and Wagoner by use of the relaxation method, is calculated by the method of series expan-

sion. The unknown coefficients of each term in the series are determined by solving linear simultaneous equations derived from the boundary conditions on the shock polar and the sonic line. The bad coincidence of the present calculation with the one by Vincenti and Wagoner with respect to the shape of the shock and the sonic line, shown in a numerical example, indicates the slow convergence of the solution. R. Kawamura, Japan

1502. Gras, F., Trivalent solutions of equations governing two-dimensional compressible flow (in French), *C. R. Acad. Sci. Paris* **242**, 8, 991–994, Feb. 1956.

An analytic solution of the potential flow equation, single-valued in the subsonic and triple-valued in the supersonic regions of the hodograph plane, is presented. Reviewer believes solution represents flow through a transonic tunnel as in an example of Lighthill [Howarth, "Modern developments in fluid mechanics, High speed flow," Oxford, 1953, Chap. VII, Section 9].

C. M. Ablow, USA

1503. Frankl', F. I., Example of transonic gas flow with a region of supersonic velocities with a compression shock as lower bound of the flow terminating inside the flow (in Russian), *Prikl. Mat. Mekh.* **19**, 4, 385–392, July-Aug. 1955.

Smooth supersonic zones embedded in subsonic flow are now believed to be theoretically exceptional; ordinarily (hence always in experiment) the supersonic zone must terminate in a nearly normal shock wave. Author attempts to construct simple flow with strictly normal shock, using transonic small-disturbance approximation. Variables are separated in hodograph plane; analytic details of resulting hypergeometric functions studied. Defect of solution is slight discontinuity along line in supersonic region, which author claims is of smaller order, and would be smoothed by viscosity. However, Germain has recently remarked [*C. R. Acad. Sci. Paris* **243**, 17, 1190–1192, Oct. 1956] that the solution contains limit lines and is accordingly inadmissible; that no solution is possible with a locally normal shock.

M. D. Van Dyke, USA

1504. Lindsey, W. F., and Johnston, P. J., Some observations on maximum pressure rise across shocks without boundary-layer separation on airfoils at transonic speeds, *NACA TN* 3820, 22 pp., Nov. 1956.

An investigation of the two-dimensional flow along flat plates having rounded leading edges has provided additional information on shock-induced separation. The results indicate that laminar boundary layers can sustain the theoretical pressure rise for normal shocks without separating provided that the local Mach numbers are less than about 1.4. The permissible pressure rise across shocks without boundary-layer separation on rounded-leading-edge airfoils having flat sides or convex surfaces was observed to increase with increase in angle of attack and proximity of shock to airfoil leading edge. From authors' summary

1505. Lavender, R. E., and Deep, R. A., Application of second-order shock-expansion theory to several types of bodies of revolution, *J. aero. Sci.* **23**, 11, 1052–1053 (Readers' Forum), Nov. 1956.

Second-order shock-expansion theory is utilized to obtain equations for the initial normal-force curve slope, initial pitching-moment curve slope, and zero-lift wave drag for several type bodies of revolution. Bodies considered are the cone-cylinder, cone-cylinder frustum, cone-cylinder-frustum-booster, cone-frustum, and cone-frustum booster.

From authors' summary by Paul F. Maeder, USA

1506. Britton, D., Davidson, N., Gehman, W., and Schott, G., Shock waves in chemical kinetics: further studies on the rate of dissociation of molecular iodine, *J. Chem. Phys.* **25**, 5, 804–809, Nov. 1956.

The rate of dissociation reaction,

$$M + I_2 \underset{k_R}{\overset{k_D}{\rightleftharpoons}} M + I + I,$$

has been measured by the shock-tube method for argon, helium, nitrogen, oxygen, and carbon dioxide as inert gases, M, in the temperature range 1000—1600 K. The shock-wave results by themselves and the comparison of the shock-wave measurements with the room-temperature measurements of k_R by flash photolysis both show that k_R has a negative temperature coefficient. The absolute value of this negative temperature coefficient derived from the shock-wave measurements is greater than the value derived from comparison of the average high-temperature result with the room-temperature result for any particular gas. This may be due to experimental error in the determination of dk_R/dT at the high temperatures, but it is believed that the values of k_R determined in the middle of the temperature range studied are reliable.

The experimental evidence indicates that, for the measurements with CO_2, the rate of vibrational equilibration is so fast that the observations made here pertain entirely to vibrationally equilibrated CO_2. Evidence from other experiments indicates that the rate of vibrational relaxation in oxygen is such that most of the dissociation reaction occurs in relaxed O_2, but that nitrogen remains vibrationally unexcited under the conditions of the dissociation reactions studied here.

The ratio, $k_{R,I_2}/k_{R,A}$, of the efficiencies of iodine and argon as third bodies is not greater than 30 at 1300 K whereas it is 250—600 at room temperature. The hypothesis is proposed that, in general, the ratio $k_{R,\,gas}/k_{R,\,A}$ for complex gases will decrease with increasing temperature. From authors' summary

1507. Uchida, S., and Yasuhara, M., The rotational field behind a curved shock wave calculated by the method of flux analysis, *J. aero. Sci.* **23**, 9, 830–845, Sept. 1956.

Isoenergetic rotational flow behind a curved shock wave is studied by flux analysis using streamline coordinates. The vorticity equation can be integrated along the curvilinear coordinate perpendicular to the streamlines by first-assumed pattern of flow and entropy and following successive approximations. A calculated example of supersonic flow around a circular cylinder with detached bow shock wave is shown to be in fairly good agreement with experiment. An asymptotic approximate solution of non-viscous supersonic or hypersonic flow along a flat plate is also presented.

From authors' summary by P. Schwaar, France

1508. Okamoto, T., An experiment of location of detached shock wave ahead of wedge profile by hydraulic analogy, *Bull. Tokyo Inst. Tech.* (*B*), no. 1, 1–5, 1956.

Water-channel measurements of the detached-shock location for 30° and 60° wedges are given which provide approximate confirmation of E. V. Laitone's formula. J. V. Becker, USA

1509. Resler, E. L., Jr., and Scheibe, M., Instrument to study relaxation rates behind shock waves, *J. acoust. Soc. Amer.* **27**, 5, 932–938, Sept. 1955.

Instrument measures density distribution in transition zone behind shock wave in a shock tube. Light from a conventional schlieren system passes to a photomultiplier tube, connected through an amplifier to an oscilloscope. By photographing oscilloscope trace, density distribution can be found. Calculations and experiments with carbon dioxide have shown that space resolution is good and that sensitivity is adequate even for gases of low density. Reviewer suggests that instrument would be improved by use of wedge filter instead of knife edge, as suggested by Holder and North [AMR **6**, Rev. 1713]. Instrument cannot be used with very strong shock waves because of confusion due to light emitted by hot gas. W. A. Mair, England

1510. Kovasznay, L. S. G., Interaction of a shock-wave and turbulence, 1955 Heat Transfer and Fluid Mech. Inst., Univ. of Calif., Los Angeles, June 23–25, 1955. Pap. 1, 12 pp.

An axisymmetric wake is passed through an oblique shock produced by a wedge. Hot-wire anemometer surveys of the turbulent fluctuations were made to explore the different modes. Compari-

son with available theory indicated an order of magnitude agreement.

From author's summary

1511. Bleviss, Z. O., Some integrated volume properties in linearized flow and their connection with drag reduction at supersonic speeds, *J. aero. Sci.* **23,** 12, 1078–1080, Dec. 1956.

Paper is concerned with the problem of relating singularity distributions to the geometric properties of configurations in linearized supersonic flow. The integrated singularity distribution is related to the total volume of the system and an integral of the potential in the Trefftz plane. In the absence of transverse force elements, this last contribution is zero and the total strength of volume elements is equal to the volume of the configuration.

E. B. Klunker, USA

1512. Tellep, D. M., and Talbot, L., Normal forces on flat plates in low-density supersonic flow, *J. aero. Sci.* **23,** 12, 1099–1108, Dec. 1956.

Normal forces on rectangular flat plates in supersonic, rarefied flow were measured over the range $200 < Re < 2400$ and $3.7 < M < 4.1$ at angles of attack up to eight degrees. The effect of aspect ratio on normal forces was determined with a series of models having an aspect ratio range from 1.0 to 2.0.

Results were compared to linearized inviscid theory and indicated normal forces which were 33% to 77% greater than values predicted by theory, the experimental normal forces decreasing with increasing Reynolds number.

Weak interaction theory was used to derive a simple expression for the normal force and was found to predict the order of magnitude of the increased normal force as well as the trend of the normal force with Reynolds number.

From authors' summary by E. B. Klunker, USA

1513. Parker, H. M., Minimum-drag ducted and closed three-point body of revolution based on linearized supersonic theory, *NACA TN* 3704, 20 pp., Dec. 1956.

Using the fundamental equation derived previously by himself for the linearized drag integral for a body of revolution, author determines the three-point body of revolution that has a minimum wave drag. The condition is that the three points of the contour of the body must lie on the same streamline. The source distribution for minimum drag is obtained in a closed form involving a single elliptic integral. Determination of the shape requires additional numerical procedure. As a particular case, author calculates a closed body with the maximum section at the midpoint.

M. Z. Krzywoblocki, USA

1514. Licher, R. M., Reduction of drag due to lift in supersonic flight by distributing lift along a fuselage, *J. aero. Sci.* **23,** 11, 1037–1043, Nov. 1956.

On the basis of linearized supersonic flow theory, author investigates the problem of drag due to lift for wing-body combinations when a prescribed fuselage lift distribution to minimize drag can be used. Only the planar case is considered where no interference occurs between lift and thickness distributions, and the fuselage lift distribution is considered as concentrated along a line parallel to the free stream. Methods developed by Hayes to estimate total drag, and Graham to estimate interference drags, are applied. For the case most amenable to the theory, that of an elliptic planform wing, author computes the optimum fuselage loading and drag of this combination and shows a reduction in total drag of the order of 30%. Author notes some inherent weaknesses in such a theoretical treatment when applied to practical cases; these stem from frictional drag effects and shedding of vorticity from a lifting fuselage, both not accounted for in such an analysis.

G. V. Bull, Canada

1515. Evvard, J. C., and Blakey, J. W., The use of perforated inlets for efficient supersonic diffusion, *NACA TN* 3767, 35 pp., Sept. 1956.

Supersonic diffusers are limited in total pressure recovery when a normal shock is formed in front of the inlet. Such a shock is formed when the operating conditions are changed and is not swallowed when the conditions return to normal. Intentionally established oblique shocks near the inlet can give improvement over the operation of a simple diffuser but still are not completely satisfactory.

This report presents a method of controlling the flow in the diffuser inlet. Holes in the inlet walls vent the flow to the surroundings. When the inlet flow is subsonic (behind a normal shock), the pressure difference across the holes is higher than for supersonic flow and the fluid passing through the holes decreases the mass flow through the diffuser. The result is better control of the shock position in the diffuser and higher pressure recoveries.

Experimental results on a small diffuser of this design are presented. The theory is confirmed, in that stable operation under varying conditions exists with pressure recoveries as high as 0.931 of the adiabatic recovery achieved.

The design should have important applications in such devices as ramjets and wind tunnels.

R. K. Sherburne, USA

1516. Zierep, J., On a method of characteristics used for the approximative calculation of asymmetrical supersonic flow around several ringshaped bodied placed one behind the other (in German), *Z. Flugwiss.* **4,** 9, 290–300, Sept. 1956.

Asymmetric supersonic flow is calculated for small angles of attack of a configuration consisting of a cylinder with annular rings placed at various streamwise positions. Method of characteristics of Haack and Erdmann-Oswatitsch is employed in calculations. Downstream rings are placed so as to advantageously use reflected pressure field of upstream rings. Multiple rings so located yield considerably more lift (up to 10 times more) at small angles of attack than a single ring of the same chord. Optimum ring spacings would be different for each stream Mach number.

D. R. Chapman, USA

1517. Nicolas, J., Influence of a reduction in the "débit capté" on the external drag of an axially symmetric supersonic air-intake (in French), *Rech. aéro.* no. 52, 33–36, July/Aug. 1956.

Author considers a supersonic air entry in the form of a surface of revolution. He considers the cases of a detached shock wave and a shock wave which has been swallowed by the entry. He calculates the external pressure for Mach numbers 1.4 and 1.6 and shows that there is a reduction in the external drag in the case of detached shock.

G. Temple, England

1518. Germain, P., and Vallee, D., Effect of dihedral on a delta wing in supersonic flow (in French), *Rech. aéro.* no. 52, 13–20, July/Aug. 1956.

The methods of conical flow theory are applied to determine the solution for linearized steady supersonic flow around triangular wings having arbitrary dihedral. The principal concern is with wings that are swept behind the Mach cone from the leading apex. Results are applied to calculate forces and moments on separate panels as well as the complete wings. Some generalizations to wings consisting of n panels are also included. A note added in proof indicates that authors discontinued further work on this subject on learning of the results of Powell on the same subject (See AMR **9,** Rev. 3007).

J. R. Spreiter, USA

1519. Miles, J. W., The compressible flow past an oscillating airfoil in a wind tunnel, *J. aero. Sci.* **23,** 7, 671–678, July 1956.

Author considers interference effects on an oscillating two-dimensional airfoil in a supersonic wind tunnel, particularly in relation to single-degree-of-freedom pitching instability. Results indicate that the effect of the tunnel walls would be to extend rather than contract the range of supersonic Mach numbers for which the instability is theoretically possible. The subsonic problem is also investigated.

Linearized theory is used, and the solutions are obtained by ap-

plying Laplace and Fourier transform techniques and interpreting the disturbances produced by the oscillating airfoil in terms of image fields and guided waves. W. P. Jones, England

1520. Guderley, G., and Hantsch, E., Best shape for axial-symmetrical supersonic nozzles (in German), *Z. Flugwiss.* **3**, 9, 305–313, Sept. 1955.

Author calculates a family of supersonic nozzle shapes to give maximum thrust for given length, mass flow, and exit pressure. Uniform sonic conditions are assumed at the throat and supersonic conditions are attained through a centered expansion. The thrust across a control surface generated by the final "minus" Mach line in the nozzle is expressed in terms of characteristic variables and the radial coordinate, and maximized. Nozzle shapes are shown for a range of reservoir exit-pressure ratios.

Maurice Holt, USA

1521. Fraenkel, L. E., and Portnoy, H., Supersonic flow past slender bodies with discontinuous profile slope, *Aero. Quart.* **6**, 2, 114–124, May 1955.

Slender-body theory is extended to derive first approximations to the aerodynamic forces on slender bodies of general cross section with a meridian profile, discontinuous in slope and local radius at stations spaced sufficiently far apart along the longitudinal axis s. The use of the asymptotic solution, valid at a distance downstream of a discontinuity large compared with the thickness of the body, is made possible by relating the integral over the body of the $\partial\phi/\partial_s$ term in the pressure to the values of the potential ϕ at points immediately upstream and far downstream of a discontinuity. The theory is applied to a winged-body of revolution on which the wings have unswept leading edges. For a profile with discontinuous slope only, the variation of drag with Mach number is shown to depend only on the discontinuities in the rate of change of the cross-sectional area with s, and is thus independent of cross-sectional shape. Expressions for the lift and moment assume the same forms as for smooth pointed bodies.

F. A. Goldsworthy, England

1522. Li, T.-Y., and Nagamatsu, H. T., Hypersonic viscous flow on noninsulated flat plate, Proc. fourth Midwestern Conf. fluid Mech., Purdue Univ., Sept. 1955, 273–287.

The "strong" interaction problem in hypersonic viscous flow on a noninsulated flat plate is treated analytically by the method of similar solutions. Some comparison with experimental data is presented. S. Ostrach, USA

1523. Bernstein, B., On the uniqueness of ideal gas flows with a straight streamline, *Proc. nat. Acad. Sci. Wash.* **42**, 11, 850–854, Nov. 1956.

Author shows that: (1) A necessary and sufficient condition for two ideal gas flows to be equivalent is that they have the same streamline pattern and local Mach number. (2) If, in a given flow pattern, a portion L of a streamline is straight, then either there is at most one Mach-number field corresponding to the pattern, or $d\bar{K}/dn = 0$ at every point of L, where $\bar{K}$ represents the curvature of the normal trajectories to the streamlines and d/dn denotes directional differentiation with respect to arc length of these normal trajectories. The flow is assumed to occur in a regular region, although this restriction may be weakened in certain circumstances.

G. Power, England

1524. Bergman, S., New methods for solving boundary-value problems, *ZAMM* **36**, 5/6, 182–191, May/June 1956.

Many engineering problems reduce to boundary or eigenvalue problems for linear partial differential equations. Approximate solutions can efficiently be obtained by variational methods if a complete set of particular solutions of the differential equation is available. In the case of Laplace's equation in two dimensions, such particular solutions can easily be generated from arbitrary analytic functions of a complex variable by applying the operator Re("take the real part"). Author shows how this procedure can be extended to the case of more complicated equations by replacing Re by certain appropriate integral operators. As an example he treats the equations of plane flow of a compressible fluid. Also, he indicates how the method can be generalized to equations with more than two independent variables.

Although the principles of the method are simple, the details are quite involved in some cases and the reader is often referred to the extensive bibliography. W. Noll, USA

1525. Takeda, S., Transmission of oscillatory pressures through instrument pipe lines, *Tech. College of Hosei Univ., Tokyo, Rep.* 1, 37 pp., May 1956.

The oscillation of gas in an instrument tube is studied with special attention to the resonance frequency and the variations of pressure and of the mean displacement. From the equations of motion, continuity, and state, the partial differential equations for the pressure and for the mean displacement with time and longitudinal distance as the independent variables are derived. In the first approximation, the coefficient of the term for damping in these partial differential equations (or the term involving the first time derivative) is based on the assumption that the flow is essentially Poiseuille flow. In the second approximation, this coefficient is computed from the oscillatory flow of an incompressible fluid in a long tube. The partial differential equations are reduced to ordinary ones for oscillatory motion, and solved by standard methods. For further refinement, reasonable values for head losses at the ends are assumed, but their effects are computed in a somewhat arbitrary manner—chiefly because of the mathematical difficulty introduced by their nonlinearity. Finally, author calculates the polytropic index as a function of the frequency of oscillation, and applies the result to the calculation of the mean displacement with inclusion of thermodynamic effects: in one case without and in the other with consideration of heat conduction.

When author's theoretical results for resonance frequency, pressure variation, and displacement variation are compared with his own experimental results and those of Simmons and Johansen [*Aero. Res. Counc. Rep. Mem.* 957, vol. 2, p. 661], the agreement ranges from fair to satisfactory, and is improved as the theory is refined.

Engineers concerned with pressure transmission in instrument pipes are likely to find the results of the paper useful, but must be warned of their miserable presentation. C.-S. Yih, USA

1526. Krzywoblocki, M. Z. E., Bergman's linear integral operator method in the theory of compressible fluid flow (in German), *Öst. Ing.-Arch.* **10**, 1, 1–38, 1956.

In this fourth part of his work on Bergman's linear operator method, author briefly outlines the other methods used in fluid dynamics: expansion in powers of a thickness parameter, variational methods, etc. A review of the tables and particular formulas, list of tables, a brief outline of some examples, etc., close this part.

From author's summary

1527. van Driest, E. R., The problem of aerodynamic heating, *Aero. Engng. Rev.* **15**, 10, 26–41, Oct. 1956.

Paper is a good review of knowledge to date on convective heat transfer to objects moving through air at low and high speeds. Theoretical and experimental information is given on recovery factors and heat-transfer coefficients for isothermal surfaces of unswept flat plates, wedges and cones with attached shock waves, and stagnation points of blunt bodies of revolution, for both laminar and turbulent boundary layers. A convenient nomograph for calculating flat plate turbulent boundary-layer heat-transfer coefficients is given. Effects of surface cooling, surface roughness, and supply stream turbulence on transition are discussed and shown graphically. A. E. Bryson, Jr., USA

1528. Stumke, H., Calculation of the critical speed of friction and relaxation-free thermochemical gas flow through a tube and

nozzle (in German), *Ing.-Arch.* **24**, 4, 282–290, 1956.

Author develops a method, from standard thermodynamic considerations, for calculating local acoustic velocity and critical velocity for gas flow in nozzles and tubes. It is applicable to the case of slowly varying equilibrium conditions, and shows that acoustic velocity at low sound frequencies agrees with the critical flow velocity. It is indicated that these velocities may not agree under conditions of high frequency and elevated temperature because of non-equilibrium chemical conditions in the system. An example of the calculation (CO_2) is included, along with the tabular data necessary for the computation. The analytical framework is concise, although an extensive body of numerical data is required for its application to specific problems. J. S. Arnold, USA

Wave Motion in Fluids

1529. Evans, G. W., II, Faulkner, F. D., Lockhart, B. J., and Perry, C. L., Shock produced by a spherical piston of radius $\alpha(t)$, *J. appl. Phys.* **27**, 11, 1345–1351, Nov. 1956.

The motion of shock created in water by expanding spherical piston is considered. The expanding motion of the piston is assumed known. A coordinate system is chosen such that space-time region is bounded by the motion of the piston and the motion of the shock, with mesh points on both boundaries. To accomplish such a coordinate system, space mesh points are prescribed and the time required for the shock to travel from one space mesh point to the next is calculated by an iterative scheme. The behavior of the shock, during the time for which the shock radius is of the same order of magnitude as the piston radius, is given.

From authors' summary by G. V. R. Rao, USA

1530. Tucker, M. J., A shipborne wave recorder, *Trans. Instn. nav. Arch. Lond.* **98**, 3, 236–250, July 1956.

The instrument described measures waves from a ship at sea. It combines measurements of the sea pressure at a point on the ship's hull with the vertical displacement of this point obtained by double integration of the output of a vertical accelerometer. No equipment has to be put outboard. An instrument of this design has now been in service for more than two years, during which time several thousand records have been taken. A note by D. E. Cartwright describing a method of applying the wave recorder to the study of ship motion is included.

From author's summary

1531. Wiegel, R. L., Laboratory studies of gravity waves generated by the movement of a submerged body, *Trans. Amer. geophys. Un.* **36**, 5, 759–774, Oct. 1955.

In order to gain some insight into the phenomenon of gravity waves generated by underwater seismic disturbances, the tsunami, a laboratory study was made of the waves resulting from an idealized two-dimensional model of the movement of a submerged body. Bodies of several shapes, sizes, and weights were allowed to drop vertically or to slide down inclines of several angles, in water of various depths, from several heights above the bottom, but always below the water surface. The surface time histories were recorded at a point close to the origin of the disturbance, and at a point or points some distance from the origin. In addition, motion pictures were taken of several of the tests. It was found that a crest always formed first, followed by a trough from one to three times the amplitude of the first crest (depending primarily upon the slope of the incline), followed by a crest with about the same amplitude as the trough. Because of the dispersive qualities of the waves, additional crests and troughs continued to form with increasing distance from the origin. The magnitude of the amplitudes depended primarily upon the submerged weight of the body, but also upon the depth of submergence, the water depth, and other characteristics of the generation. Within the limits of experimental conditions, it was found that the time intervals between the first and second crests remained constant regardless of the water depth, the distance of fall, the weight of the body or the time of the fall. It was, however, found to be related to the length of the body, with the period increasing with increasing length, and to the slope of the incline, with the smaller the incline the greater the period.

From author's summary

Turbulence, Boundary Layer, etc.

(See also Revs. 1475, 1510, 1556, 1570, 1631)

1532. Stepanyants, L. G., Laminar boundary layer on a plate in the presence of sucking and blowing (in Russian), *Trudl Leningr. Politekhn. Univ.* no. 176, 146–153, 1955; Rev. no. 251, *Ref. Zh. Mekh.* 1956.

The problem is examined of the laminar boundary layer of an incompressible fluid on a plate in the presence of uniformly distributed sucking and blowing across the length of the plate. The solution is based on the linearization of the equation. The solution obtained is made precise by introducing into the profile the corrected coefficient of velocity determined from the equation of the quantity of motion. Comparison of the results obtained with the accurate solution for the case of absence of the flow of the fluid through the plate, gives a divergence of about 10%.

Courtesy of Referativnyi Zhurnal O. S. Vorob'ev, USSR

Translation, courtesy Ministry of Supply, England

1533. Legendre, R., Regular laminar separation (in French), *C. R. Acad. Sci. Paris* **241**, 12, 732–734, Sept. 1955.

Author examines the incompressible laminar flow around a body with detachment of the stream from the wall, and obtains a formula connecting the direction of the normal to the separation line (or surface) with the direction of the pressure gradient in correspondence to the separation point. Author deduces from this formula that the study of the flow in the boundary layer, according to the conventional method neglecting the pressure variation through the layer, cannot produce sufficiently approximate results near the separation. This conclusion, in reviewer's opinion, is very likely, though it does not necessarily derive from the formula deduced by the author. C. Ferrari, Italy

1534. Dem'ianov, Yu. A., An application of the A. A. Dorodnitsyn variables to boundary-layer theory (in Russian), *Prikl. Mat. Mekh.* **19**, 4, 507–508, July/Aug. 1955.

1535. Janssen, E., An analog solution of the Navier-Stokes equation for the case of flow past a flat plate at low Reynolds numbers, 1956 Heat Transfer and Fluid Mechanics Institute, Stanford, Cal., Preprint no. 11, 12 pp.

Author studies the flow of a laminar boundary layer past a flat plate at Reynolds numbers in the range 0.1 to 10.0, using an analog computing machine. Therefore the Navier-Stokes equation is transformed in such a form as to utilize, for analogy, two resistance networks with square meshes, which represent, respectively, the flow function and the vorticity in the hydrodynamic problem.

Along the boundary author uses an approximate relationship obtained by means of a series expansion of the boundary equations neglecting all terms of fourth or higher degree.

Author gives values of local coefficient of friction C_f and of drag coefficient C_D; such values are compared with those furnished by the Blasius theoretical investigation and by the known experimental researches. The difference from experiment, in the range where comparison is possible, is due, according to the author, to the number of meshes of employed electrical analog networks.

The very low range of values of Reynolds numbers to which the investigation refers has limited interest from a practical point of view. The investigation, however, has a certain theoretical

interest for the study of influence of leading and trailing edges on C_f and C_D values. A. Russo-Spena, Italy

1536. Walz, A., General approximation theory for compressible laminar and turbulent boundary layers with respect to flow effects normal to the wall across the boundary layer (Investigations on an improvement of known approximation methods of boundary-layer calculation) Air Research and Development Command USAF Contract no. 61 (514)...739..C, 84 pp. + 36 tables + 25 figures, 1955.

Paper treats compressible laminar and turbulent boundary layers under condition of nonnegligible pressure gradients across layer. The boundary-layer thickness, form parameter of the velocity profile, and pressure difference across boundary layer are parameters used in development of approximate theory. Theory is restricted to two-dimensional steady flow along walls of vanishing curvature and zero heat transfer to the wall.

Solutions are obtained by a rather lengthy iteration procedure proposed in paper. Calculations indicate iteration procedure does not converge for cases where second-order terms are large, i.e., in regions of shock-wave boundary-layer interaction.

Author suggests a useful application of theory is the investigation of reciprocal effects between boundary layer and pressure distribution along body contour. R. W. Detra, USA

1537. Turcotte, D. L., On incompressible turbulent boundary layer theory applied to infinite yawed bodies, Cornell Univ., School Aero. Engng. 45 pp. + 8 figs., Sept. 1955.

Paper begins with a comprehensive critical account of methods of calculating the flow over a surface with pressure gradient at no angle of yaw. Conclusion is reached that the first attempt, due to Buri, assuming the shape parameter H to be 1.4 and the one-quarter power law for the shearing stress, is the simplest and fits experiment best in spite of drastic simplification made.

In laminar flow past infinite yawed bodies it is known that the boundary-layer flow in the chordwise direction is independent of the spanwise flow. This is the "independence principle." Author produces evidence to prove that in turbulent flow another principle known as the "line-of-flow principle" gives results agreeing with experiment better than those of the independence principle. In the line-of-flow principle the wall shearing stress is considered to be a function of the distance over which the fluid flows rather than the distance measured normally from the leading edge.

Author then works out the flow over a yawed body with pressure gradient on both principles, using the various no-angle-of-yaw methods given in the first part of the paper. He finds that the line-of-flow principle gives a better fit with experiment.

Finally, detailed consideration of the flow past a flat plate (i.e. with no pressure gradient) is given; the arguments in favor of the line-of-flow principle are here more convincing, though there is still a significant, if small, deviation from experiment, which author feels may be explained by turbulent mixing perpendicular to the plane of flow. J. C. Cooke, British Malaya

1538. Marris, A. W., On fully developed turbulent flow in curved channels, *Canad. J. Phys.* **34,** 11, 1134–1146, Nov. 1956.

Turbulent flow in a curved channel is treated by the vorticity transfer form of the mixing-length theory, with the object of predicting the mean velocity distribution and other properties of the flow. The flow is considered in two halves, one bounded by the inner and one by the outer wall, and a modified form of Karman's similarity hypothesis is used to determine the mixing-length. In each region, the mean vorticity is inversely proportional to distance from the wall. The results are compared with Wattendorf's measurements with reasonable agreement except near the inner wall. Reviewer notes that the mean velocity profile is dynamically stable in this part of the flow and its turbulent structure is certainly not dependent only on local conditions.

A. A. Townsend, England

1539. Hawthorne, W. R., and Armstrong, W. D., Shear flow through a cascade, *Aero. Quart.* **7,** 4, 247–274, Nov. 1956.

When a flow with nonuniform velocity passes through a cascade, the blades impose local pressure changes. This results in rotational secondary flows and also over-all spanwise accelerations and displacements. These effects are analyzed for frictionless flow by treating the blade row as an actuator plane whose outlet angle is determined by the secondary velocities in the blade passages. At low outlet angles the secondary flows effectively control the downstream flow angles. When the outlet angle is large, the displacement effect can result in downstream flow angles of opposite sign to those induced by the secondary flow alone. Measurements confirm the main predictions of the first-order theory.

From authors' summary by G. Nitzberg, USA

1540. Rogachev, I. I., On the anomalously early turbulence of colloidal solutions (in Russian), *Colloid. Zh.* **16,** 6, 464–469, 1954; Rev. no. 282, *Ref. Zh. Mekh.* 1956.

It is known that, in the motion of certain colloidal solutions, turbulence occurs considerably earlier than in the motion of water. In this case, the turbulence occurs earlier, the greater the viscosity of the sol. Ostwald [Ostwald, W., *Kolloid-Z.* **43,** no. 3, 1927] explains the earlier occurrence of turbulence by the presence of the structure of the sol. The particles of the dispersed phase, orienting themselves in a laminar flow, effect the production of vortices. The author, analyzing the probable scale of turbulent disturbances in the flows investigated by him, shows that the internal scale of turbulence λ_0 is 10^2 to 10^3 times greater than the dimensions of the colloid particles. Hence it follows that the presence of structure in the sol cannot lead to a considerable formation of vortices, and to the breakdown of the laminar conditions of flow of the dispersion medium. Further, examining the velocity profiles of the dispersed flow, author indicates their instability. The low stability of the motion is explained by the presence of an abrupt jump on the viscosity curve of non-Newtonian fluids and of the associated breakdown of the continuity of the tangential flow velocities. E. M. Minskii, USSR

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Translation, courtesy Ministry of Supply, England

1541. Siao, T.-T., Momentum and energy equations for incompressible turbulent flow, Proc. fourth Midwestern Conf. fluid Mech., Purdue Univ., Sept. 1955, 115–130.

Reynolds equations are manipulated using vector and tensor notation. Energy and momentum equations are obtained and the terms given physical interpretations. Some simple flows are discussed as illustrative examples but no results of engineering interest are presented. W. Squire, USA

1542. Willmarth, W. W., Wall pressure fluctuations in a turbulent boundary layer, *J. acoust. Soc. Amer.* **28,** 6, 1048–1053, Nov. 1956.

Wall pressure fluctuations in pipe flow were measured at various distances from the pipe entrance with a barium titanate transducer mounted flush with the pipe wall. The transducer output voltage, being approximately proportional to the instantaneous pressure at the transducer face, was amplified and analyzed by a variable band pass filter and a vacuum tube voltmeter. This system was used to establish the frequency spectrum of the pressure fluctuations in the boundary layer between 300 and 15,000 cps for flow conditions from $M = 0.2$ to 0.8 and $Re = 1.5 \times 10^6$ to 20×10^6, Re being based on the distance from the pipe entrance.

In the range of conditions examined, the root-mean-square pressure fluctuations for laminar boundary layers were found to be less than 1/6 as great as those for turbulent conditions. Below $M = 0.43$, local turbulence induced by a point disturbance in the laminar boundary layer was found to have no effect on the wall pressure fluctuations outside the region in which turbulence was induced. Above $M = 0.43$, this effect was not observed, as tran-

sition occurred upstream of the transducer station closest to the pipe entrance (8 in. from entrance), although it would seem that it would have been easy to do so if measurements had been taken at a station closer to the pipe entrance. The half-angle at which turbulence induced by point disturbances spreads downstream was found to lie between 8.1 and 15.9°, which result agrees with work by others showing this half-angle to be 8.6°. For turbulent boundary layers, the spectrum of root-mean-square wall pressure was found to be proportional to the free-stream dynamic head by a factor whose dependence on M and Re could not be clearly established but which seemed to depend on frequency in a fairly well-defined manner. The over-all root-mean-square pressure fluctuation was found to be about 0.35% of the free-stream dynamic pressure for all turbulent flow conditions examined.

This work, which appears to be one of the first attempts to study noise generation by boundary layers, would seem to have some commercial and military significance after future work on moving walls has been completed. Examples cited are boundary-layer noise generated on the bodies of aircraft, automobiles, and ships and transmitted through the walls to the interior.

A. W. Gessner, USA

1543. Prausnitz, J. M., and Wilhelm, R. H., Turbulent concentration fluctuations through electrical conductivity measurements, *Rev. sci. Instrum.* **27,** 11, 941–943, Nov. 1956.

Authors describe an electrical-conductivity-fluctuation measuring instrument. The instrument is quite analogous to the hot-wire anemometer when used for the measurement of temperature fluctuations. The instrument operates with a 10 kc carrier and covers the conductivity ranges of 0.001N – 0.050N hydrochloric acid.

L. S. G. Kovasznay, USA

1544. Rotta, J., Experimental contribution to the study of generation of turbulence (in German), *Ing.-Arch.* **24,** 4, 258–281, 1956.

Measurements of pipe flow in the transition region of laminar to turbulent flow are dealt with. The mass flow through the pipe, and therefore the Reynolds number, was fixed strictly constant in time. The measurements show that, in the transition region, laminar and turbulent parts run irregularly in succession through the pipe. Thereby the fully developed velocity distribution of the laminar and turbulent flow, respectively, is formed over the pipe cross section. The turbulent portions originating at the pipe inlet enlarge upon the flow more and more during its run along the pipe, until at last the flow is fully turbulent. Therefore, the flow in the transition region does not only depend upon the Reynolds number but also on the relative distance from the pipe inlet. The statistical mean values of the flow are described by an intermittent factor giving the relative extension of the turbulent part of the flow, and an intermittent number formed by the frequency of the turbulent periods in the flow.

The extensive experimental results give valuable insight into the origin of turbulent pipe flow. N. Scholz, Germany

Aerodynamics of Flight; Wind Forces

(See also Revs. 1348, 1393, 1474, 1479, 1496, 1497, 1505, 1518, 1572, 1577, 1578, 1579, 1580, 1581, 1584)

1545. Keune, F., Cambered and twisted wing without thickness at transonic speeds (in German), *Dtsch. Versuch. Luftfahrt E. V. Rep.* 13, 30 pp., Apr. 1956.

R. T. Jones [AMR **2,** Rev. 902] developed a theory of pointed plane wings of small span in which the perturbation flow in planes normal to the main flow is approximated by two-dimensional flow. Author extended this to nonplanar wings [AMR **7,** Rev. 2926]. Present report summarizes computations based on this theory for wings whose xy-planforms are one parameter family of curvilinear triangles with straight trailing edge and a symmetrical pair of parabolic leading edges. Twisted wings lie on $z = -\chi_n x(y/\sigma x_0)^n$, $n = 1, 2, 3$ with constant χ_n. Cambered wings lie on $z = f(x,0)[1 - (y/s[x])^2]$, where $f(x,0)$ is a fourth-degree polynomial, and $s(x)$ is semi-span at distance x from the upstream vertex. For strictly triangular wings, calculations of lift, pitching, and rolling-moment coefficients agree well with results based on theory of G. N. Lance [AMR **8,** Rev. 729]. J. H. Giese, USA

1546. Kuchemann, D., and Weber, J., The subsonic flow past swept wings at zero lift without and with body, *Aero. Res. Counc. Lond. Rep. Mem.* 2908, 65 pp., 1956.

A review is given of the effects associated with the subsonic inviscid flow past swept wings at zero lift so as to provide information needed for an understanding of the flow phenomena. One purpose of this paper is to investigate the distorsions of the flow at the center of the wing, the wing tips, and at a junction with fuselage or engine nacelle, and to provide practical methods of calculating them. At the same time, an attempt is made to understand the physics of the flow. Author seeks to find ways of counteracting these distortions and restoring, e.g., two-dimensional conditions as far as possible.

The approach adopted is to find detailed solutions for three basic cases: (a) the sheared wing of infinite span; (b) the center-section of a swept wing of infinite span; (c) the flow in the curved intersection line between a wing and a body. These solutions can be combined to obtain approximate solutions to the general case of a tapered swept wing of finite aspect ratio, and to calculate the pressure distribution over the surface of a given wing with symmetrical airfoil sections of non-zero thickness, at zero incidence without or with body. Methods are derived for inviscid incompressible flow and, subsequently, the Prandtl-Glauert procedure is extended and applied to derive approximations for the compressible flow in the subcritical region.

The special cases treated in detail are: the flow in the tip regions of wings; tapered wings; wing-fuselage interference for symmetrical arrangements; modifications to the wing or to the body shape, for instance to restore sheared-wing conditions.

From authors' summary by G. Sestini, Italy

1547. Woods, L. C., Theory of aerofoil spoilers, *Aero. Res. Counc. Lond. Rep. Mem.* 2969, 21 pp., 1956.

Author's previous work [AMR **8,** Rev. 3458] is extended to the case of the spoilers on flaps of airfoils in two-dimensional compressible flow. Equations are given for the pressure distribution, lift, drag, pitching moment, and hinge moment of spoilers located anywhere along the flap chord. Special attention is then given to the trailing-edge spoiler. Theoretical predictions are compared with experiments. The agreement is quite good for the trailing-edge spoiler; for the general case, the agreement between theory and experiment is acceptable but not as good as for the trailing-edge case. H. P. Liepman, USA

1548. Krasilshchikova, E. A., Finite span wings in compressible flow, *NACA TN* 1383, 130 pp., Sept. 1956. (From scientific records of the Moscow State Univ., **154,** no. 4, 1951, with appendix condensed from a document "Modern problems of mechanics," 1952.)

Paper is essentially a summary of previous work given by the author in 1947–1950. It presents the linearized theory of wings in supersonic flow, both for the steady and the unsteady case. Starting in part I with the retarded potential of a source which moves with supersonic speed in a straight line and which has an intensity variable with time, author derives a basic formula for the velocity potential. Specializing then to harmonically oscillating wings, the influence of the tip and the influence of the vortex system trailing from the wing are thoroughly treated. Power series in a frequency parameter are the chief instrument to treat the integral equations and the integro-differential equations for the source strengths.

Part II deals with steady flows. Wings of small span are carefully studied. To deal with subsonic trailing-edge effects, the acceleration potential is introduced. All the integral equations

appearing here are of the same type and they are inverted by means of a double application of the Abel integral equation inversion formula. Some examples, such as the swallowtail wing, the semi-elliptic wing, and the hexagonal wings, are given in an appendix. H. Behrbohm, Sweden

1549. Harris, K. D., The effect of transition wires on the pressure distribution over a N.A.C.A. 63A215 aerofoil section, *Coll. Aero. Cranfield Note* no. 41, 22 pp. + 10 tables + 3 figs., Feb. 1956.

1550. Makofski, R. A., and Menkick, G. F., Investigation of vertical drag and periodic airloads acting on flat panels in a rotor slipstream, *NACA TN* 3900, 23 pp., Dec. 1956.

Measurements were made of vertical drag and steady-state and periodic pressures acting on a rectangular panel placed normal to the rotor shaft at various distances Z (= $.05R$ to $0.64R$, R = rotor radius) beneath a two-bladed rotor rotating in a hovering condition. A panel span b of R and of $2R$ was used. For $b = 2R$, it was found that ratio of vertical drag D to rotor thrust T is about 66% of ratio of panel area to rotor disk area for $Z = 0.20R$ to $0.64R$. This is found to agree with calculations by strip-analysis procedure and assumption of a fully contracted wake. For $Z < 0.2R$, D/T increases appreciably and must be calculated by taking into account periodic ("pulse") pressures caused by passage of the rotor blade over the panel. Measurements indicated a pulse pressure as high as 10 times the disk loading per blade at the 0.8 radius spanwise station with $Z = 0.05R$. No change in rotor power at constant rotor thrust was observed with changes in panel position. M. Morduchow, USA

1551. Eggleston, J. M., Calculation of the forces and moments on a slender fuselage and vertical fin penetrating lateral gusts, *NACA TN* 3805, 20 pp., Oct. 1956.

A theory is presented for estimating the pressure and lift distribution history over the aircraft and the resultant forces and moments as it penetrates a general gust. Slender-body theory and a fixed-form traveling speed are used. Specifically, calculations are made for the variation with frequency of the lateral force and yawing moment coefficients due to sinusoidal side gusts passing over the profile of a simple fuselage-vertical-fin configuration. The significant parameters in this study are the body shape, the rate of change of the body shape, and the local flow angle. Improved accuracy over the time-lag method is claimed. The method is illustrated by numerical examples.

M. G. Scherberg, USA

1552. Burrows, F. M., Characteristics of the flow field over the mid-upper fuselage of Lancaster P. A. 474, *Coll. Aero. Cranfield Note* no. 36, 13 pp. + 25 figs., Jan. 1956.

1553. Katzen, E. D., and Kaattari, G. E., Drag interference between a pointed cylindrical body and triangular wings of various aspect ratios at Mach numbers of 1.50 and 2.02, *NACA TN* 3794, 41 pp., Nov. 1956.

In order to investigate the effects of drag interference on wing-body combinations, tests were conducted at Mach numbers of 1.50 and 2.02 with a pointed cylindrical body, with six triangular wings having aspect ratios from 0.67 to 4.00, and with the wings and the body in combination. Experimental drag results were obtained for a nominal angle-of-attack range of $\pm 5.5^\circ$ and a constant Reynolds number of 5.5 million based on the body length. The characteristics of the body, the wings, the combinations, and the wing-body interference were calculated from the available theories and compared with the experimental results.

The minimum drag coefficients of the body alone, as calculated by the method of characteristics with laminar and turbulent skin-friction coefficients added for the body in a smooth condition and with fixed transition, were in good agreement with the experimental values. The drag rise with angle of attack, as calculated by the method of *NACA Rep.* 1048, 1951, was much lower than the experimental drag rise of the smooth body, but was in fair agreement with that of the body with transition fixed. The data indicate that the transition point on the smooth body moved forward with increasing angle of attack, causing the skin friction to increase. In general, the predicted minimum drag coefficients of the wings (which included an estimate of the skin friction) were greater than the experimental values. The predicted minimum drag coefficients of the wing-body combinations were in good agreement with the experimental values. The better agreement for the combinations than for the wings alone was a result of the relatively greater accuracy in the calculation of the body drag which constitutes a large percentage of the combination drag.

Calculation of the pressures at zero angle of attack on the wings in the presence of the body by the method of *NACA RM* A9E19, 1949, indicated that the interference pressure drag was small for the present wing-body combinations if the wing alone were defined as the exposed half wings brought together. The experimental results indicated that the drag interference was principally the result of fixing transition by adding a wing.

From authors' summary

1554. Funk, J., and Rhyne, R. H., An investigation of the loads on the vertical tail of a jet-bomber airplane resulting from flight through rough air, *NACA TN* 3741, 36 pp., Oct. 1956.

Input-gust histories and loads on the vertical tail during two test flights in rough air of a four-engine jet-powered aircraft were measured. The test flights were at 1500-ft altitude and 390 knots at minimum control for safety. The following results may be quoted from the summary of the paper: "The results showed large and regular load oscillations which were lightly damped. Comparison of experimental results with discrete-load calculations indicated that discrete-gust calculations underestimated the loads by 30 to 40% and gave no indication of the oscillatory characteristics or low damping. Calculations based on power spectral analysis, on the other hand, reflected the general frequency characteristics of the measured loads and gave a better estimate of the tail loads. The present results strongly indicate that discrete-gust calculations for gust loads on vertical tails may seriously underestimate the gust loads for airplanes having lightly damped lateral oscillations."

M. G. Scherberg, USA

1555. Proposto, S. D., Analysis of a new suggestion to improve deck loading of highly loaded airplanes on aircraft carriers (in German), *Z. Flugwiss.* **4,** 5/6, 204–212, May/June 1956.

Paper presents an analysis of the use of a free jet as an alternative to arrester wires for deceleration of planes landing on carriers. Such an alternative is desirable because the wires produce decelerations near the stopping point which may be unbearable for the crew when high wing loadings exist. The treatment is a first-order one in which the structure of the jet is simplified and assumed to be unaffected by the entrance of the airplane. By a series of straightforward algebraic calculations, author obtains a number of results whose practicability is assessed. The important quantities are wing loading, jet power, and carrier runway length and speed. For example, with a typical wing loading of 300 kg/m² and a rather high carrier speed, a jet of realistic power consumption will bring the relative velocity between plane and carrier to near zero at initial contact when landing. Pertinent numerical examples, charts and graphs render this a useful paper to those concerned with this problem.

D. Bershader, USA

1556. Eggleston, J. M., and Diederich, F. W., Theoretical calculation of the power spectra of the rolling and yawing moments on a wing in random turbulence, *NACA TN* 3864, 56 pp., Dec. 1956.

Methods are given for the calculation of the power spectrum of

the rolling moment, defined as the Fourier transform of the autocorrelation function of the rolling moment, for an airplane flying through atmospheric turbulence. The power spectrum for the yawing moment is then obtained from its aerodynamic relationship to the rolling moment. Although the numerical computation for a given case follows a straightforward procedure, the process is tedious and requires as input information a statistical description of the turbulence, and spanwise influence coefficients defining the aerodynamic responses of the airplane. The effort is probably worthwhile if the result is to be used as a basis for the computation of the lateral motions of an airplane through turbulent air.

L. H. Schindel, USA

1557. Klawans, B. B., A simple method for calculating the characteristics of the Dutch roll motion of an airplane, *NACA TN* 3754, 16 pp., Oct. 1956.

To calculate the Dutch-roll motion by ordinary methods is somewhat difficult, as it is necessary to solve a biquadratic equation and then to make further computations to determine the ratios of the pertinent variables. The method presented in this report facilitates the calculation of the Dutch-roll characteristics. The equations of motion are arranged in a form that is well suited to calculation by successive approximations. It is easy to obtain an initial approximation, and the convergence is almost always good. The method inherently provides the ratios of roll/yaw angle and sideslip/yaw angle as well as the period and damping ratio. The method is valuable for the insight it provides into the nature of this mode of motion and the effects of the various parameters involved.

For completeness it would have been desirable to extend the report to include determination of the roll and spiral modes, which, of course, follow readily after the Dutch roll is obtained. Reviewer believes that the method presented should be of value both to the worker in the field and to the student.

W. F. Milliken, Jr., USA

1558. Triplett, W. C., Brown, S. C., and Smith, G. A., The dynamic-response characteristics of a 35° swept-wing airplane as determined from flight measurements, *NACA Rep.* 1250, 25 pp., 1955.

The longitudinal and lateral-directional dynamic-response characteristics of a 35° swept-wing fighter-type airplane determined from flight measurements are presented and compared with predictions based on theoretical studies and wind-tunnel data. Flights were made at an altitude of 35,000 ft covering the Mach number range of 0.50 to 1.04. A limited amount of lateral-directional data were also obtained at 10,000 ft. The flights consisted essentially of recording transient responses to pilot-applied pulsed motions of each of the three primary control surfaces. These transient data were converted into frequency-response form by means of the Fourier transformation and compared with predicted responses calculated from the basic equations of motion. The equations, or transfer functions, that best describe the various measured responses were evaluated by a curve-fitting process involving the use of templates and an analog computer. By this method it was generally possible to find equations, of simple form, that closely matched the experimental frequency responses between 1 and 10 radians per second and at the same time adequately described the recorded time histories.

Experimentally determined transfer functions were used for the evaluation of the stability derivatives that have the greatest effect on the dynamic response of the airplane. The values of these derivatives, in most cases, agreed favorably with predictions over the Mach number range of the test.

From authors' summary

1559. Brown, S. C., and Holleman, E. C., Experimental and predicted lateral-directional dynamic-response characteristics of a large flexible 35° swept-wing airplane at an altitude of 35,000 feet, *NACA TN* 3874, 74 pp., Dec. 1956.

The lateral-directional dynamic-response characteristics of a large flexible airplane are presented for flight conditions of 0.6 to 0.82 Mach number and an altitude of 35,000 feet. Transient responses at various stations on the airplane to aileron and rudder pulse-type disturbances have been recorded and converted into frequency-response form. A frequency range of 0.5 to 25 radians per second is presented, which includes the Dutch roll and rolling modes and also three structural modes. The measured frequency responses are compared with those obtained from transfer functions based on the lateral-directional equations of motion, which include first-order effects of structural deflections. Reasonably good agreement is obtained in the low frequency range corresponding to the lateral-directional modes. However, in the higher frequency range, the effects of the structural modes are sufficiently large so that these predictions become inadequate even for the quantities measured near the center of gravity. Comparisons are also made with frequency responses obtained from transfer-function coefficients calculated for the rigid airplane to indicate the effects of flexibility.

Calculated simplified transfer-function coefficients based on the lateral-directional equations of motion are compared with coefficients obtained by matching transient time histories with an analog computer. Aerodynamic derivatives extracted from measured transfer-function coefficients are also compared with estimated derivatives. In general, good agreement between measured and estimated values was obtained.

From authors' summary

1560. Nielsen, J. N., Katzen, E. D., and Tang, K. K., Lift and pitching-moment interference between a pointed cylindrical body and triangular wings of various aspect ratios at Mach numbers of 1.50 and 2.02, *NACA TN* 3795, 49 pp., Dec. 1956.

In order to investigate the effects of interference on wing-body combinations, tests were conducted at Mach numbers of 1.50 and 2.02 of a pointed, cylindrical body, of six triangular wings having aspect ratios from 0.67 to 4.00, and of the wings and the body in combination. The body had a fineness ratio of 7.33, a conical nose with a semiapex angle of 15°, and an ogival transition section to a cylindrical afterbody. The wings had 8-percent-thick double-wedge sections with the maximum thickness at the midchord, and the wing-body combinations were made by inserting the wings at zero incidence into the cylindrical part of the body. Experimental lift and pitching-moment results were obtained for a nominal angle-of-attack range of ±5.5° and a constant Reynolds number, based on the body length, of 5.5 million. Theoretical characteristics of the body and wings alone and in combination, as well as the interference, were calculated from the available theories and compared with the experimental results.

The theory described by Allen and Perkins in *NACA Rep.* 1048, 1951 [AMR **5,** Rev. 3455; **4,** Rev. 1281], produced results in good agreement with the measured values of lift and pitching moment for the body. The agreement was better at a Mach number of 1.50 than at 2.02. For the wing-body combinations having low-aspect-ratio wings, the theoretical predictions of Spreiter in *NACA Rep.* 962, 1950 [AMR **4,** Rev. 800; **2,** Rev. 1420], were in good agreement with the experimental values of lift and moment. For the wing-body combinations having higher-aspect-ratio wings, a modification of the theory of *NACA Rep.* 962 produced predictions in good agreement with experiment. Comparison of the wing-alone data with the results of Love in *NACA Rep.* 1238, 1955 [AMR **9,** Rev. 3008], indicated a marked effect of the position of maximum thickness on the lift-curve slope. The lift-curve slopes for the wings tested were considerably greater than for wings with the maximum thickness at 18-percent chord in the upper range of wing-aspect ratios.

The results for the components alone and in combination were used to determine the total interference, which is defined as the sum of the interference effects of the body on the wing forces and of the wings on the body forces. The interference effects were

important for the wing-body combinations having small wings relative to the body. Both the results of the theory of *NACA Rep.* 962 and of the modified theory were in good agreement with the experimentally measured interference results.

From authors' summary

1561. Queijo, M. J., and Wells, E. G., Effects of vertical fins near the nose of the fuselage on the directional and damping-in-yaw stability derivatives of an airplane model under steady-state and oscillatory conditions, *NACA TN* 3814, 54 pp., Dec. 1956.

An experimental investigation has been made to determine the effects of vertical fins near the nose of the fuselage on the directional and damping-in-yaw stability derivatives of a sweptwing airplane model. The investigation included measurements of these characteristics for the model oscillating about a vertical axis in a steady airstream.

The results of this investigation showed that, for angles of attack up to at least 12°, fins placed above the fuselage nose decreased the directional stability but increased the damping in yaw of the model in both the steady-state and oscillatory conditions because of the sidewash acting on the tail as well as the direct lift of the fins. Also, fins placed above the fuselage nose were more effective in increasing the steady-state or oscillatory damping in yaw than the addition of an equal amount of area at the vertical tail.

Fins placed below the nose of the fuselage decreased the directional stability and increased the damping in yaw to a lesser extent than fins placed above the fuselage nose in the steady-state condition but reduced the damping in yaw in the oscillatory condition. For a constant value of directional stability, the damping in yaw could be greatly increased by the use of a fin placed above the nose of the fuselage and an increase in tail size.

From authors' summary

1562. Owen, E. M., and Heath-Smith, J. R., V-g records from Vampire aircraft, *Aero. Res. Counc. Lond. Rep. Mem.* 2963, 17 pp., 1956.

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 1393, 1498, 1519, 1525)

1563. Li, T., Aerodynamic influence coefficients for an oscillating finite thin wing in supersonic flow, *J. aero. Sci.* **23,** 7, 613–622, July 1956.

The wing planform is considered to be divided into a mesh of congruent rectangles whose diagonals parallel the Mach lines. Rectangles can pitch, roll, and translate vertically. Based on linearized theory formulas for oscillatory pressure influence coefficients (pressure on each rectangle due to its own unit oscillatory motion and that of other rectangles) are given. With a given wing planform and Mach number then, for general flexible motions, total pressure on a rectangle is obtained by summing over all rectangles the product of local amplitude of motion times the pressure for unit motion. For the two-dimensional wing (which choice obviates use of correction factors for swept leading edges) in translation and pitch, good agreement is obtained with the section lift and moment of Garrick and Rubinow [*NACA Rep.* 846] for $M = 10/9$, $5/4$, and $10/7$ for reduced frequencies ranging up to $k = 0.4$, and of Temple and Jahn for $M = 1.6$ with k ranging up to 0.8.

For subsonic leading edges and wing tips, a hypothetical impenetrable diaphragm, whose local slope coincides with the direction of the downwash, extends from the wing to the appropriate Mach cone. Influence coefficients relating rectangles on the diaphragm and wing can be obtained only after the unknown downwash on the diaphragm is found from expressions given.

No calculations or comparisons with known results are provided. Reviewer remarks that such calculations and comparisons are needed to verify Ta Li's treatment of wings with subsonic leading edges and tips.

H. J. Cunningham, USA

1564. Mazelsky, B., Theoretical aerodynamic properties of vanishing aspect ratio harmonically oscillating rigid airfoils in a compressible medium, *J. aero. Sci.* **23,** 7, 639–652, July 1956.

Theoretical solutions are given in terms of tabulated Mathieu functions for the aerodynamic properties of rigid vanishing aspect ratio harmonically oscillating airfoils in a compressible medium for the complete range of reduced frequencies. The significant variable introduced in defining the oscillatory coefficients when the flow is compressible is the single entity, k_0M, and Mach number variations enter only through this quantity. Numerical coefficients are tabulated for use in evaluating the expressions for lift, pitching, and rolling moment for the rectangular and triangular planforms. Comparisons of the oscillatory coefficients based on compressible and incompressible flow indicate that, for the range of reduced frequencies applicable for flutter, the effects of compressibility can be considered negligible.

From author's summary by H. J. Cunningham, USA

1565. Foody, J. J., and Reid, L., The solution of aeroelastic problems on wings of arbitrary planform by matrix methods, *J. roy. aero. Soc.* **59,** 540, 843–846, Dec. 1955.

Paper is concerned with the formulation of aeroelastic problems in a form suitable for routine computation. For this purpose, aerodynamic load and structural distortion are expressed by means of matrixes of influence coefficients. The solution of specific aeroelastic problems for arbitrary wing shape is then found by matrix techniques which lend themselves easily to machine or other routine computation.

Two problems are considered in more detail: (1) Maneuver margin due to aeroelastic effects; (2) rolling effectiveness, and reversal speed for aileron controls.

H. L. Oestreicher, USA

1566. Stratford, B. S., Early thoughts on the jet flap, *Aero. Quart.* **7,** 1, 45–58, Feb. 1956.

An historical sketch shows how the basic ideas of the jet flap were evolved. The exploratory work included the prediction that lift would be induced on an airfoil by a two-dimensional jet deflected from the trailing edge, and that the magnitude of the total lift would be of the order of four times the direct jet lift. The prediction was confirmed experimentally and a first quantitative theory evolved. Meanwhile, the hypothesis was put forward that, ideally, the forward thrust on the airfoil would be independent of the deflection angle of the jet.

(This paper is the first of a series of papers that will describe the development and present state of knowledge of the jet flap.)

From author's summary

1567. Stratford, B. S., Mixing and the jet flap, *Aero. Quart.* **7,** 1, 85–105, May 1956.

One of the main problems associated with the "jet flap" concerns the discrepancy in thrust between idealized theory and the experimental results. This discrepancy is attributable to the mixing with the surrounding flow of the thin two-dimensional jet while still in close proximity to the airfoil. The effect of the mixing may be calculated to a first approximation from a formula derivable from first principles, while certain second-order effects, which can be significant, may be considered qualitatively.

It is concluded that (1) the full thrust should be experienced by a jet-flapped aircraft at cruise; (2) it should be possible to attain a low form drag at cruise in comparison with a conventional aircraft; (3) at take-off, an aircraft using a shrouded jet flap would have better thrust recovery than one using a pure jet flap (which shows appreciable losses); (4) the use of by-pass engines would further improve the thrust characteristics; (5) the practical gains from thrust augmentation, as obtained by controlling the mixing, seem likely to be small.

From author's summary

Propellers, Fans, Turbines, Pumps, etc.

(See Revs. 1324, 1353, 1473, 1479, 1483, 1484, 1487, 1574, 1575, 1600, 1609)

Flow and Flight Test Techniques

(See also Revs. 1467, 1478, 1509, 1519, 1531, 1542, 1550)

Book—1568. **Shoop, C. F., and Tuve, G. L., Mechanical engineering practice. A laboratory reference text,** 5th ed., New York, McGraw-Hill Book Co., Inc., 1956, xii + 471 pp. $7.

An elementary presentation of brief laboratory experiments in various fields of mechanical engineering: basic measurements and instrumentation, heat transfer, thermodynamics, fluid dynamics and machinery, control, fuels and combustion, steam power, refrigeration, air-conditioning, and internal-combustion engines.

Book has been prepared for sophomore or junior laboratory courses. After brief presentation of background material, author goes into a description of one or several possible apparati and then into the procedure to be followed. In some cases he also gives an idea of the results to be expected and how they should be reported. The use of test codes from various American societies is emphasized wherever applicable.

Because of the variety of experiments covered (104 experiments in 450 pages) the book is a good elementary reference in laboratory equipment. As a text, reviewer feels that the background material is too empirically presented and often much too brief. It is a pity that one of the most useful experimental tools, similitude, is omitted in the text, particularly in the chapter on pumps and compressors where it is almost a "natural". M. A. Santalo, USA

1569. **Kenney, M. J., Sarjant, H. J., and Thring, M. W., The viscosity of mixtures of gases at high temperatures,** *Brit. J. appl. Phys.* **7,** 9, 324–329, Sept. 1956.

An Edwards-type viscometer [*Proc. roy. Soc. Lond.* (*A*) **117,** p. 245, 1927] was used to determine the viscosity of three carbon dioxide and nitrogen mixtures (with small amounts of oxygen) at temperatures up to 900 C. The whole viscometer (consisting essentially of a reservoir from which the gas escapes through a capillary) was kept at the test temperature. Experimental procedure, calibration by air, and calculation of corrections are described in detail. Variation with temperature is shown to be of the form predicted by Sutherland's formula; experimental results are in good agreement (within 3%) with those calculated by Hirschfelder's method [AMR **7,** Rev. 1937]. G. Sved, So. Australia

1570. **Johnson, H. A., Hartnett, J. P., Clabaugh, W. J., and Fried, L., Orifice-metering coefficients and pipe friction factors for the turbulent flow of lead-bismuth eutectic,** ASME Semiann. Meet., Cleveland, O., June 1956. Pap. 56-SA-16, 5 pp.

Pipe friction factors and orifice-metering coefficients are reported for the turbulent flow of lead-bismuth eutectic and are found to be in satisfactory agreement with the results for water flow when compared on the usual dimensionless basis.

From authors' summary

1571. **Truitt, R. W., Free streamline analysis for slotted two-dimensional supersonic minimum-length nozzles,** *J. aero. Sci.* **22,** 9, 658–659 (Readers' Forum), Sept. 1955.

Author develops a theoretical relation between required slot width and exit Mach number for a constant-area slotted nozzle. The analysis applies to a two-dimensional "minimum length" nozzle. The "minimum length" is that specified by an expansion wave, reflected at nozzle centerline, of total strength sufficient to attain the desired Mach number. The flow through the slots is treated as isentropic with contraction coefficient per Busemann's free streamline analysis. Since the analysis assumes the slot jet-exit plane pressure is identical with test section (i.e. nozzle exit) pressure, the result is restricted to the range where the slots are unchoked. However, this limitation does not occur until the test section Mach number reaches approximately 1.87.

Reviewer feels author's analysis provides an interesting first approximation for the design of transonic wind-tunnel nozzles.

J. C. Burke, USA

1572. **Clevenson, S. A., and Leadbetter, S. A., Some measurements of aerodynamic forces and moments at subsonic speeds on a wing-tank configuration oscillating in pitch about the wing midchord,** *NACA TN* 3822, 37 pp., Dec. 1956.

Measurements are presented of the aerodynamic forces and moments acting on a wing-tank configuration, with or without fins, oscillating in pitch about the wing-root midchord. The reduced-frequency range was from 0.050 to 0.657, whereas the Mach number and Reynolds number ranges were from 0.18 to 0.75 and 0.9×10^6 to 9.5×10^6, respectively.

Comparisons of the experimental aeroydnamic forces and moments and their respective phase angles acting on the wing-tank combination with those acting on the wing alone indicated that the over-all lifts and moments were greater when the tank was attached. The forces on the tank alone were compared with those determined by an engine-nacelle theory developed by Andropolus, Chee, and Targoff in *AF Tech. Rept.* 6353. The agreement between measured and calculated lift was very good. From authors' summary

1573. **Devacht, M., A six-component sting balance** (in French), *Rech. aéro.* no. 52, 21–31, July/Aug. 1956.

Paper presents an analysis of the forces and moments acting on a sting-supported aerodynamic model as measured by a six-component resistance-type strain gage balance. The analysis takes into account the shape of the supporting member, the location of the strain gages on the supporting member, and the bridge circuits incorporating the strain gages.

The aim of the analysis is to arrive at a configuration allowing a high ratio of stiffness to frontal blocking area of the sting support in conjunction with a low value of force interaction, in addition to errors due to temperature changes. Two examples are given; one for use in a transonic wind tunnel, the other for a supersonic wind tunnel. F. L. Wattendorf, USA

1574. **Erwin, J. R., Savage, M., and Emery, J. C. Two-dimensional low-speed cascade investigation of NACA compressor blade sections having a systematic variation in mean-line loading,** *NACA TN* 3817, 129 pp., Nov. 1956.

The low-speed cascade performance of the high-speed NACA 65-$(C_{l_o}A_2I_{8b})$10 compressor blade sections has been systematically investigated. Porous test-section side walls and porous flexible end walls were employed to establish a close simulation of two-dimensional flow. Blade-section cambers of 0.4, 0.8, 1.2, and 1.8 were tested over the usable angle-of-attack range for inlet angles β of 30°, 45°, and 60° at solidities σ of 1.0 and 1.5. A sufficient number of cascade configurations were tested to permit interpolation and extrapolation of the data within the usual range of application.

Comparative tests of blade sections having an isolated airfoil lift coefficient of 1.2 were made for two other blade sections with mean lines having different loading distributions at an inlet angle of 45° with a solidity of 1.5 and at an inlet angle of 60° with a solidity of 1.0. The results of this comparison indicated that the data presented herein, when utilized in conjunction with published cascade data for the NACA 65-$(C_{l_o}A_{10})$10 series blades, will permit a fairly accurate prediction of design performance for most compressor blade sections since the mean lines tested are believed to encompass the practical range of compressor-blade mean-line loading distributions.

A comparative evaluation of the cascade test results obtained for the mean lines investigated indicated that the NACA 65-$(C_{l_o}A_2I_{8b})$10 and NACA 65-$(C_{l_o}A_6I_{4b})$10 blades should be capable of efficient operation to a higher inlet Mach number than the 65-

$(C_{l_o}A_{10})$10 blades at high inlet angles and low solidities ($\beta = 60°$; $\sigma = 1.0$). At low inlet angles and high solidities ($\beta = 45°$; $\sigma = 1.5$), the NACA 65-$(C_{l_o}A_6I_{4b})$10 blades appeared to offer better high-speed capabilities than either the 65-$(C_{l_o}A_2I_{8b})$10 or the 65-$(C_{l_o}A_{10})$10 blades. From authors' summary

1575. Leist, K., and Dettmering, W., Turbine blades of plastics for investigations with cold air, *Dtsch. Versuch. Luftfahrt E. V. Rep.* 4, 44 pp., Dec. 1955.

1576. Murasaki, T., Linearized theory of wind-tunnel interference at transonic speed (in Japanese), *J. Japan Soc. aero. Engng.* **4,** 25–26, 33–37, Feb.-Mar. 1956.

Author analyzes flow fields at far lateral distance from a slender lifting wing and a symmetrical non-lifting body by use of the slender-wing theory by Jones and the sonic flow theory by Guderley and others, respectively, and shows that the former is compatible with the linearized condition for uniform slotted walls and the latter with that for uniform perforated walls. It is also shown that, provided the diameter of the wind tunnel with perforated wall is smaller than a certain limit determined by the body shape, the linearized treatment gives nondivergent solution to the flow around a body of revolution placed in the tunnel even at transonic Mach numbers. R. Kawamura, Japan

1577. Lowry, J. G., and Vogler, R. D., Wind-tunnel investigation at low speeds to determine the effect of aspect ratio and end plates on a rectangular wing with jet flaps deflected 85°, *NACA TN* 3863, 21 pp., Dec. 1956.

A wind-tunnel investigation was made at low speeds to determine the effect of aspect ratio and end plates on the aerodynamic characteristics of an unswept and untapered wing equipped with jet flaps deflected 85° and operating with momentum coefficients as high as 17.5.

The results indicate that the lift coefficient induced by the jet sheet (lift coefficient minus jet reaction in the lift direction) increases rapidly with increased aspect ratio and has maximum values of 2.9, 6.4, and 10.5 for aspect ratios of 2.8, 5.6, and 8.4, respectively. Various end plates increase the effective aspect ratio. The combination of the jet reaction at the trailing edge and the induced lift acting at the 0.4-chord station resulted in very large nose-down pitching-moment coefficients about the quarter chord of the wing. From authors' summary

1578. Lockwood, V. E., Turner, T. R., and Riebe, J. M., Wind-tunnel investigation of jet-augmented flaps on a rectangular wing to high momentum coefficients, *NACA TN* 3865, 51 pp., Dec. 1956.

A preliminary investigation of jet flaps has been made in the 300-mph 7- by 10-ft tunnel on an unswept, untapered wing with an aspect ratio of 8.4 and a thickness of 16.7%. A jet of air was blown backward through a small gap, tangentially to the upper surface of a round trailing edge, and was separated from the trailing edge at various angles up to 110° with respect to the wing chord line. In addition, a limited number of tests were made of a jet-augmented plain flap and a jet-augmented trim flap.
From authors' summary

1579. King, T. J., Jr., and Pasteur, T. B., Jr., Wind-tunnel investigation of the aerodynamic characteristics in pitch of wing-fuselage combinations at high subsonic speeds, *NACA TN* 3867, 36 pp., Dec. 1956.

The results presented in the present paper represent a continuation of a research program conducted in the Langley high-speed 7- by 10-ft tunnel to investigate the aerodynamic characteristics in pitch, side-slip, and steady roll of model configurations having variations in the wing geometric parameters. Presented are the aerodynamic characteristics in pitch of wing-fuselage combinations with wings having an aspect ratio of 4, a sweepback angle of 45°, and taper ratios of 0.3, 0.6, and 1.10. The Mach number range was from 0.40 to about 0.95 and the Reynolds number range was from 2,000,000 to 3,000,000.

The results of the investigation indicate at low lift coefficients a reduction in lift-curve slope and a forward movement in aerodynamic center with an increase in taper ratio throughout the test range of Mach number, as would be predicted from available theory. All wings showed a rapid forward movement in aerodynamic center at the higher lift coefficients; however, the lift coefficient at which this forward movement started was found to increase with increased taper ratio.

Only small differences in minimum drag, drag due to lift, and lift-drag ratios resulted from variation in taper ratio for the constant-thickness-ratio wings investigated. Adjustment of the thickness ratio to provide equal aeroelastic characteristics may allow some improvement in minimum drag and in lift-drag ratios as the taper ratio is reduced, at least at the higher Mach numbers.
From authors' summary

1580. Campbell, J. P., and Johnson, J. L., Jr., Wind-tunnel investigation of an external-flow jet-augmented slotted flap suitable for application to airplanes with pod-mounted jet engines, *NACA TN* 3698, 47 pp., Dec. 1956.

A wind-tunnel investigation has been carried out to determine the characteristics of an external-flow jet-augmented slotted flap which appears suitable for application to airplanes with pod-mounted jet engines. The investigation included tests of an unswept wing and of a model of a swept-wing jet transport or bomber. Compressed air jets exhausting from nozzles attached to the lower surface of the wings were used to simulate the jets from pod-mounted jet engines.

The external-flow jet-augmented flap produced values of circulation lift large enough to warrant serious consideration of its use for increasing the maximum lift coefficients of airplanes with pod-mounted jet engines. From authors' summary

1581. Polhamus, E. C., and Spreemann, K. P., Subsonic wind-tunnel investigation of the effect of fuselage afterbody on directional stability of wing-fuselage combinations at high angles of attack, *NACA TN* 3896, 25 pp., Dec. 1956.

A wind-tunnel study of the directional stability characteristics at high angles of attack of two wing-fuselage combinations has been conducted at subsonic speeds. The wings utilized were a 4-%-thick unswept wing of aspect ratio 3.0 and a 6-%-thick 45° sweptback wing of aspect ratio 4. The results indicate very large differences in the directional stability between the two wing-fuselage configurations at high angles of attack. The unswept-wing-fuselage combination became stable at high angles, whereas the sweptback-wing-fuselage combination became increasingly unstable. Tests with the fuselage afterbody removed indicate that these effects were associated with wing-induced sidewash over the fuselage afterbody. From authors' summary

1582. Shivers, J. P., and Carpenter, P. J., Experimental investigation on the Langley helicopter test tower of compressibility effects on a rotor having NACA 63_1-015 airfoil sections, *NACA TN* 3850, 28 pp., Dec. 1956.

1583. Chapman, D. R., Some possibilities of using gas mixtures other than air in aerodynamic research, *NACA Rep.* 1259, 22 pp., 1956.

See AMR **8,** Rev. 2485.

1584. Ikard, W. L., An air-flow-direction pick-up suitable for telemetering use on pilotless aircraft, *NACA TN* 3799, 25 pp., Oct. 1956.

A free-swiveling vane-type pickup for measuring air flow direction in both the angle-of-attack and angle-of-sideslip directions is described. The device, which is intended to telemeter flow direction from pilotless aircraft, has variable-inductance outputs suitable for use in the 100 to 200 kcps subcarrier frequency range of

the NACA FM-AM telemetering system. Preliminary test results indicate that it can also be adapted for use with the audio subcarrier frequencies of the Research and Development Board standard FM-FM telemetering system.

Test results are presented which indicate that the pickup is aerodynamically stable and has an accuracy, obtained from a bench calibration, of better than 0.3° under conditions including acceleration up to 20g in any direction, Mach numbers from 0.5 to 2.8, and dynamic pressures up to at least 65 psi.

Equations and curves which can be used to obtain flow direction at the center of gravity of a maneuvering model are presented.

From author's summary

Thermodynamics

(See also Revs. 1438, 1441, 1506, 1512, 1528, 1568, 1569, 1611, 1628)

Book—1585. Vukalovich, M. P., Kirillin, V. A., Remisov, S. A., Siletsky, V. S., and Timofeev, V. N., Thermodynamic properties of gases, Moscow, Mashgiz, 1953, 376 pp.; Rev. no. 158, *Ref. Zh. Mekh.* 1956.

In the first part of the book, "The theory and method of determining the thermodynamic values of gas," basic information is given of the thermodynamics of ideal gases, making use of quantum analysis and the theory of spectra. The calculation method used by the authors is examined according to the spectrograms of the thermodynamic properties of a gas which has been reduced to an ideal state. The influence of the pressure on thermodynamic parameters is examined, and a method is indicated for correction of pressure if necessary. In the second part, "Tables of the thermodynamic values of mono-, di-, tri- and polyatomic gases and combustion gas mixtures and their combustion products," tables are given for the heat capacity and the entropy of the gases N, O, C, O_2, N_2 of atmospheric nitrogen, of air, H_2, CO, NO, OH, CO_2, N_2O, SO_2, H_2S, CS_2, COS, H_2O hydrocarbons of the methane series C_nH_{2n+2}, of the ethylene series C_nH_{2n} of the acetylene series C_nH_{2n-2}, hydrocarbons of the diolefine series, ethyl alcohol, benzene, the hydrocarbon series of styrol and methyostyrol, the cyclopentane series, the cyclohexane series, the combustion gases, the products of combustion, the products of complete and incomplete combustion of petrol. Tables are also given of the viscosity and thermal conductivity of various gases, and, in a supplement, the basic spectroscopic constants of gases. In all, the book contains 341 tables and 17 graphs. V. A. Prokof'ev, USSR

Courtesy of Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

Book—1586. Zeise, H., Thermodynamics. Vol. III/1. Tables [Thermodynamik. Band III/1. Tabellen], Leipzig, S. Hirzel Verlag, 1954, xi + 311 pp. DM 20.

Some of the simpler aspects of statistical mechanics are reviewed with consideration of the effect of ionization and spin upon the properties of simple molecules. The behavior of ideal and real gases is treated briefly from the standpoint of statistical mechanics. Some 170 tables present information concerning the molecular heat capacity, enthalpy, entropy, and free energy of commonly encountered components. The chemical equilibrium constants for a number of common gas phase reactions are included. References to the source of information do not appear to be as complete as would be desirable in a book of this type. The book is primarily of interest to the chemist and the chemical engineer. B. H. Sage, USA

1587. Reuss, J., and Beenakker, J. J. M., Determination of the second virial coefficient B_{12} of gas mixtures (in German), *Physica* **22,** 10, 869–879, Oct. 1956.

The coefficient B_{12} in the Kamerlingh Onnes equation of state for a binary gas mixture is determined from experimental data on the influence of pressure on the vapor-solid equilibrium of one of the components. The systems H_2-CO and H_2-N_2 are investigated in the temperature range from about 30 to about 70° K and the pressure range from 1.3 to 50 atm, and B_{12} is evaluated as a function of temperature from 36 to 60° K. The results are compared with calculations of B_{12} based on a Lennard-Jones 12–6 potential for the interaction between unlike molecules, and satisfactory agreement is obtained. In addition, an estimate is made of the third virial coefficient, C_{122}, for the system H_2-N_2 in the range from 35 to 49° K.

The vapor pressure of solid CO is tabulated from 36 to 60° K. There is also a discussion of the optimum pressure required for the separation of one gas in a binary mixture by partially solidifying the other component, with an application to the system H_2-N_2. R. Heller, USA

1588. Ury, J. F., A diagram of state for superheated steam, *Appl. sci. Res.* (*A*) **6,** 2/3, 141–146, 1956.

Author proposes equation of state Pv/T = a function of entropy only. Author states this represents superheated steam within range 1 to 300 atm, saturation to 500 C with a deviation of order ±1%. It is proposed to give the function of entropy on *h-s* diagram so that volumes can be obtained with greater accuracy than by interpolation between constant-volume lines. See, J. H. Horlock, Proc. of 5th Int. Conf. on Properties of Steam, London, July 1956. J. H. Keenan, USA

1589. Anonymous, Standard atmosphere-tables and data for altitudes to 65,800 feet, *NACA Rep.* 1235, 114 pp., 1955.

1590. Bellemans, A., Mathot, V., and Zuckerbrodt, P., Critical phenomena of vaporization in binary mixtures (in French), *Acad. roy. Belgique, Bull. Cl. Sci.* **42,** 5, 631–642, 643–663, 1956.

Van der Waals' equation of state gives a qualitative description of critical phenomena of pure gases based on semi-empirical considerations and the selection of arbitrary constants which account for intermolecular forces. The authors utilize the techniques of modern statistical mechanics to yield a more rational description of the critical phenomena of vaporization of binary solutions. The theory of conformal solutions of Longuet-Higgins is applied to relate critical properties and intermolecular forces. Recognizing that this theory does not take into account dispersion forces, authors introduce the "average potential model" suggested by Prigogine. A perturbation calculation limited to the second order leads to a deduction of critical properties from a description of intermolecular forces.

Reviewer believes this work represents an important step toward a more complete and satisfying qualitative description of critical phenomena. Correlation between the theory and experiment are encouraging and the elimination of the arbitrary constants of van der Waals is an important advantage. J. F. Lee, USA

1591. Borchardt, H. J., and Daniels, F., The application of differential thermal analysis to the study of reaction kinetics, *J. Amer. chem. Soc.* **79,** 1, 41–46, Jan. 1957.

Equations are derived which relate the shape of a differential thermal analysis curve to the kinetics of the reaction giving rise to the curve. For certain reactions, use of these equations allows the order of the reaction, the frequency factor, the activation energy, and the heat of reaction to be determined in a single rapid measurement. The equations are applied to the decomposition of benzenediazonium chloride and the reaction between dimethylaniline and ethyl iodine. The results agree very well with data obtained by conventional methods. From authors' summary

1592. Barger, J. P., Rohsenow, W. M., and Treadwell, K. M., A comparison of refrigerants when used in vapor compression cycles over an extended temperature range, ASME Semiann. Meet., Cleveland, O., June 1956. Pap. 56-SA-6, 5 pp.

An important current engineering problem involves providing apparatus to meet the cooling requirements of supersonic aircraft.

Because the time is already passing when simple air cycles can render adequate performance due to their inability to extend over a sufficient temperature range, vapor compression cycles are being considered. However, the maximum temperature range over which a single refrigerant can operate successfully in a vapor cycle is also relatively limited. Since the total required temperature range increases rapidly with the aircraft flight Mach number, series combination or "stacking" of vapor cycles leading to binary and higher-order cycles may become necessary. This paper gives methods for selecting the refrigerant, or series combination of refrigerants, which exhibits optimum thermodynamic performance when employed in vapor cycles operating between arbitrarily selected temperatures. From authors' summary

1593. Barger, J. P., Rohsenow, W. M., and Treadwell, K. M., Turboconditioning systems with vapor compression cycles, ASME Semiann. Meet., Cleveland, O., June 1956. Pap. 56-SA-7, 12 pp. + 35 figs.

While cabin cooling for present-day trans- and supersonic aircraft is accomplished primarily with open-air cycles, these cycles, with their relatively small temperature spread, become inadequate as the temperature gap between the desired cabin temperature and the ambient stagnation temperature becomes large. The closed vapor-compression cycle may then be a logical choice for use in combination with the air cycle to increase the effective temperature range of the cooling system. With moderate temperature differences, one vapor cycle may suffice; with extremely large temperature differences, multiple vapor cycles will be required. In an earlier work, authors predicted optimum refrigerants for such applications. Coefficients of performance (COP) of the single and multiple vapor cycles described by the previous study were utilized in calculating the performance of the turboconditioning systems investigated in this paper. From authors' summary

1594. Kariagin, N. P., Prospects of heat pump use in a boiler heating installation (in Russian), *Teploenergetika* **3,** 3, 49-54, Mar. 1956.

The economic advantage of combined use of boiler heating installation and heat pump as a means for more effective exploitation of flue gases is argued. Author states that economizers and incoming air heaters presently in use do not permit to obtain the full heat potential available due to corrosion danger to metal walls when gases are cooled to economic temperature minimum. The use of asbesto-concrete pipes is also considered not sufficiently satisfactory.

A sample calculation is given, based on data for an installation operating on Moscow Basin coal in an automatic furnace and Freon 11 ($CFCL_3$) as working medium. The possibility of using elements of heat pump installation as part of cooling equipment during hot season is pointed out. Use of scrubber and low pressure turbines to drive the heat pump is suggested when electricity conservation is required. Difficulty is seen in the limited choice of available material for economizers.

Reviewer wishes to point out that the argument, sample calculation of yield-cost relationship, and profitable yield limits curve are based on USSR economic standard (cost of labor, electricity, materials) and therefore may be used only with correction for US values. I. A. Black, USA

1595. Nekolny, J., The theory of multistage regeneration (in Czech), *Strojnicky sbornik* 12, 1956.

This treatise deals with a new method of solving the problem of preheating water by means of steam taken from steam turbines in the course of the expansion.

Unlike the usual procedures for analyzing this Carnot's cycle, which start from the theoretical expansion in the turbine according to the adiabatic curve, the new method of solution complies much better with the real course of expansion as it takes place when losses are considered as well. This new and more accurate solution method is mathematically very simple, as it starts from the fact that the difference between the enthalpies ($q = i - i'$) of the tapped steam (delivered in the various preheaters to the feed water) is at all points of the expansion curve approximately constant. This supposition, which is intuitively represented by drawing in the lines q = const. in the $i - s$ diagram, makes possible a simple computation of the most advantageous distribution of the outlets, an improvement of the thermal circulation efficiency and finally, too, the computation of other interesting indexes. Along with this, it is comparatively easily possible to take into consideration the final difference between the temperatures in the preheaters, and to include in the computation the influence of the difference between the actual expansion in the turbine and the q = const. The author discusses the main schemes that occur in the design of condensing steam power electrical plants, and completes them by his own proposal for the insertion of re-coolers in every heating stage, by which it is possible to achieve the same results as by using less suitable condensate re-pumping.

The author mentions the importance of regeneration in back-pressure works and elucidates the serviceability of the new method even in cases with multistage circulations.

The present treatise is a further analysis of a problem that has also been dealt with in the papers of Prof. Miškovský; it is a valuable contribution to circulation theory for steam power electrical plants. O. Mastovsky, Czechoslovakia

1596. Andriushchenko, A. I., Regeneration of heat by steam preheating of fuel and air (in Russian), *Teploenergetika* **3,** 3, 47-49, Mar. 1956.

1597. Stratonovich, R. L., The entropy of systems with a random number of particles *Soviet Phys.-JETP* **1,** 2, 254-261, Sept. 1955 (Consultants' Bur. Transl.: *Zh. eksp. teor. Fiz.* **28,** 409-421, Apr. 1955).

Heat and Mass Transfer

(See also Revs. 1413, 1422, 1423, 1425, 1438, 1510, 1527, 1568, 1586, 1591, 1592, 1593, 1594, 1595, 1633)

1598. Campbell, W. F., A rapid analytical method for calculating the early transient temperature in a composite slab, *Nat. Res. Counc. Canad. mech. Engng. Rep.* MT-32, 36 pp. + 5 tables + 15 figs. + appendixes, Apr. 1956.

Author considers the heat-conduction problem in a composite slab, that is, a slab made up of discrete layers, each with uniform and fixed thermal properties. The problem is studied for different boundary conditions, including the presence of a plane or volume heat source; initially all the parts of the slab should be at the same temperature. A method is used that is analogous to the electric transmission-line theory and that gives short-time solutions. The steady-state solutions of problems involving a harmonic law may also be handled, if all the layers are in a good thermal contact. The data, equations, and graphs of the functions derived from the error function (in order to aid the numerical calculations) are given at the end of the paper.

A. Pignedoli, Italy

1599. Vernotte, P., Heat transfer of a slab with periodic heat flux at the origin and physical properties dependent on the temperature, Part II (in French), *C. R. Acad. Sci. Paris* **242,** 25, 2913-2915, June 1956.

An extension of the work by the same author reviewed in AMR **10,** Rev. 281. In this case the slab is thin such that the temperature at the center of the slab is also a periodic function with a phase angle with respect to the surrounding temperature.

S. Eskinazi, USA

1600. Molchanov, E. I., Calculation of temperature distribution in a gas-turbine rotor under nonstationary conditions (in Russian), *Teploenergetika* **3**, 1, 53–57, Jan. 1956.

Author solves the problem by use of an analogy between heat conduction and hydraulic streaming (by use of an hydraulic integrator). The idea of this analogy is shown on a simple example: The temperature in a square-sectioned bar can be approximately characterized by temperatures of centers of blocks into which the bar is divided. For the temperature current between two neighboring centers with temperatures T_1 and T_2, respectively, then holds (approximately) the equation

$$q = \text{const}\,(T_2 - T_1)$$

An analogical equation holds for water current between two vessels with hydraulic pressures H_1 and H_2. To use this analogy, it is necessary to construct an hydraulic net with suitable hydraulic resistances.

In a considerable part of the paper, attention is paid to the formulation of the boundary conditions of the problem (concerning the temperature of the rotor) and to the approximative determination of constants appearing in these boundary conditions. Author shows then how to divide mathematically the body of the rotor into blocks in order to use the hydraulic method for numerical calculation, and how to construct the hydraulic net. He comments on some properties of the net and shows course and results of the calculation in some graphs. Finally, these results are analyzed.

K. K. Rektorys, Czechoslovakia

1601. Lenngren, C. E., A transient method for determining temperature and heat conductivity (in Swedish), *Trans. Heat Power Group, Swedish Assoc. Engrs. Arch.* **2**, 1, 6–10, 1956.

Author uses a tubular test specimen, the inner surface of which is fed with a heat impulse. By recording the temperature variations of the tube wall the heat conductivity can be determined if the specific heat is known. The method has been used for some steel materials between 0 and 500 C. Results are compared with those of other authors. From author's summary

1602. Cobb, E. C., and Saunders, O. A., Heat transfer from a rotating disk, *Proc. roy. Soc. Lond. (A)* **236**, 1206, 343–351, Aug. 1956.

Experimental results are reported for the convective heat transfer to air from an isothermal vertical 18-in.-diam disk rotating at speeds from 0–2150 rpm with disk-to-air temperature differences from 10–120 F. Total temperature and total velocity profiles are presented for conditions of laminar and turbulent flow. For a Prandtl number of 0.72 (air), the results are well correlated by the following equations:

$$N = 0.36\,R^{0.5}; \quad R \leqq 2.4 \times 10^5 \text{ (laminar)}$$

$$N = 0.015\,R^{0.8} - 6.1 \times 10^4\,(R)^{-1/2}$$

where $N = hr/k$ is a Nusselt number based on the disk radius, and $R = \omega r^2/\nu$ is a Reynolds number based on disk radius and tip speed. The foregoing laminar expression agrees very well with the known exact solution for incompressible flow when the constant-pressure specific heat is used in the energy equation. For the turbulent range, a simple Reynolds analogy closely relates present heat-transfer findings with earlier measurements of friction torque.

H. G. Elrod, Jr., USA

1603. Sutton, G. P., Heat transfer in rockets, *J. Brit. interplanetary Soc.* **15**, 4, 192–205, July/Aug. 1956.

1604. Havemann, H. A., Rao, N. N. N., Jayachandra, P., and Garg, G. C., Studies for a new hot air engine, *J. Indian Inst. Sci.* **38**, 3, 172–202, July 1956.

This part III of authors' series is independent of previous works [AMR 9, Rev. 552]. Heat-transfer coefficient for turbulent flow in a pipe with artificially imposed flow pulsation was measured for Reynolds number ranging from 6000 to 25,000 and for pulsating frequency from 5–40 cps. Resulting Nusselt numbers were compared to those at steady flow and found to vary from some 40%, sometimes below and sometimes above, steady flow values, depending on frequency. Authors found an improvement in heat transfer by putting an orifice at the pipe end to restrict the flow, but do not mention change in pressure loss. No convincing correlation law is presented. L. S. Dzung, Switzerland

1605. Brevoort, M. J., Turbulent-heat-transfer measurements at a Mach number of 3.90, *NACA TN* 3734, 15 pp., July 1956.

Turbulent-heat-transfer measurements were obtained through the use of an axially symmetric annular nozzle which consists of an inner, shaped center body and an outer cylindrical sleeve. Measurements taken along the outer sleeve gave essentially flat-plate results that are free from wall interference and corner effects for a Mach number of 3.90 and for a Reynolds number range of 6.3×10^5 to 7.0×10^7. The heat-transfer-coefficient results are slightly higher than theoretical results for a Mach number of 4.0 and for a ratio of inside-surface temperature to free-stream temperature of 4.2. The temperature-recovery factors range from approximately 0.89 at a Reynolds number of 6.3×10^5 to approximately 0.86 at a Reynolds number of 7.0×10^7.

From author's summary

1606. Koricheva, R. S., Actual heat-transfer coefficients of sectional water-line heaters of the type used by the Moscow Power Administration for district heating circuits (in Russian), *Teploenergetika* **3**, 2, 31–34, Feb. 1956.

1607. Zaks, M. L., Calculated pressure loss in hot-water heating circuits (in Russian), *Teploenergetika* **3**, 2, 34–37, Feb. 1956.

1608. Yamaga, J., An approximate solution of the laminar flow heat-transfer on a rotating axially symmetrical body surface in a uniform incompressible flow, *J. mech. Lab. Tokyo* **2**, 1, 1–14, 1956.

This mathematical analysis is a Karman-Pohlhausen-type approximate solution of the laminar boundary-layer heat transfer from a rotating, axially symmetric body, with arbitrary surface temperature distribution, to a constant property, incompressible fluid having a uniform velocity field upstream of the body. Author uses refinements to the Karman-Pohlhausen method due to Schlichting and to Dienemann. Numerical computations are made for two cases of a sphere of uniform temperature in air ($Pr = 0.733$); in case 1, the sphere was not rotating, while in case 2 it was rotating about an axis parallel to the flow field such as to produce a surface rotational velocity component approximately equal to the local velocity at the edge of the boundary layer. Author states that the increase in heat transfer of case 2 over case 1 of about 2% seems low. Reviewer agrees. D. C. Hamilton, USA

1609. Reznikov, B. N., The influence of a nonhomogeneous temperature field in front of a turbine on its efficiency (in Russian), *Trudi Kuibysbevsk. Aviat. Inst.* no. 2, 53–58, 1954; Rev. no. 141, *Ref. Zh. Mekh.* 1956.

The influence of a nonhomogeneous temperature field on the gas consumption and the efficiency of a working turbine stage with short blades ($b_b : D_{mean} = 1 : 9.3$) is determined by calculation at the entry into the turbine, and at its outlet. The case is examined of linear increase in temperature in the direction from the root to the tip of the blade and also the case of the maximum value of the temperature on the mean diameter with identical linear fall toward the root and tip of the blade. Author comes to the conclusion that in the cases examined, the inhomogeneous temperature field does not influence in practice the gas consumption and the efficiency of the turbine. The paper contains a number of inaccuracies; e.g., in formula (2) and later, P_{inlet} and T_{inlet} are the parameters of stagnant flow, whereas there is no mention of this, and their denotation does not differ from the indications of the parameters of the moving flow. It is assumed that the pressure P, behind the

jet, for given values of P_{inlet} and rpm does not depend upon the temperature, and is approximate. In fact, the characteristic of the turbine should be calculated, and the relationship of the distribution P should be found from the temperature distribution.

Courtesy of Referativnyi Zhurnal V. Kh. Abiants, USSR
Translation, courtesy Ministry of Supply, England

1610. Van Der Hegge Zijnen, B. G., Modified correlation formulae for the heat transfers by natural and by forced convection from horizontal cylinders, *Appl. sci. Res. (A)* **6,** 2/3, 129–140, 1956.

A comprehensive summary of major approaches to evaluation of heat transfer from horizontal cylinders is given. Langmuir's "film theory" and its numerous derivations are compiled with emphasis on their restriction to either natural or forced convection. Some numerical values of Nusselt number are shown. A new correlation formula, combining natural and forced convection, is introduced for wider range of applicability. The new correlation formula is reasonably verified by experimental data. Its usefulness is extended to approximate determination of certain Reynolds numbers above which natural convection becomes negligible.

This paper is a stimulating contribution to the science of heat transmission. C. R. Bell, USA

1611. Benveniste, G., and Hiester, K., The solar furnace.... new tool for high-temperature work, ASME Fall Meet., Denver, Colo., Sept 1956. Pap. 56–F–7, 6 pp.

After a brief historical review, the basic theory of solar furnaces is outlined and several methods for tracking the sun to direct the incoming radiation onto the target are described. The characteristics of several existing solar furnaces are described. It is pointed out that solar furnaces are useful for research at very high temperatures (3000 to 3500 C), particularly where lack of contamination from flames, combustion products, electrodes, and refractory fragments is important. A. Whillier, South Africa

1612. Tabor, H., and Steinberger, I. T., An instrument for measuring absorptivities for solar radiation, *J. sci. Instrum.* **33,** 9, 356–358, Sept. 1956.

Instrument permits rapid determination of absorptivity for solar radiation at normal incidence by comparing the heating and cooling cycles of a standard black, with that of the test surface. The instrument is simple to construct and operate. It gives *comparative* results of accuracy better than 1%, and *absolute* results as accurate as the absorptivity of the reference black surface can be estimated. A. Whillier, South Africa

1613. Baum, V. A., The problem of utilizing solar radiant energy (in Russian), *Teploenergetika* **3,** 2, 5–12, Feb. 1956.

1614. Huss, G., Estimation of operating range of heat-telescopes (in Swedish), *Trans. Heat Power Group, Swedish Assoc. Engrs. Arch.* **2,** 3, 11–19, 1956.

An object with a temperature different from its surroundings, as for instance an unwelcome supersonic bomber, involuntarily emits information about its existence and position with the velocity of light. From author's summary

1615. Munch, B., Directional distribution of the reflection of heat radiation and its influence upon heat transfer (in German), *ETH* Prom. no. 2434, 87 pp., 1955.

This thesis is concerned with the radiative properties of surfaces. An apparatus designed to measure the dependence of the reflection coefficient both on the angle of incidence and the angle of reflection is described. It is used to examine a variety of surfaces from strongly scattering ones such as fire wood to mirror-like surfaces such as oxidized brass. The results are used to calculate the absorption coefficients for the surfaces.

A theory of heat transfer by radiation is also given, based on the mirror reflection law and on Lambert's law concerning emission from black bodies. For eccentric spheres there is good agreement with experiment. K. Stewartson, England

1616. Van Stralan, S. J. D., Heat transfer to boiling skim milk, *Netherlands J. agric. Sci.* **4,** 1, 107–110, Feb. 1956.

The heat flux to boiling pasteurized skim milk was determined by using a horizontal platinum heating wire, which served at the same time as a resistance thermometer. A gradually increasing coagulation layer was precipitated on the wire at a constant heat flux of 10 cal sec^{-1} cm^{-2} under atmospheric pressure, which was attended by a rapid decrease in the coefficient of heat transfer.

The heat flux to skim milk under a pressure of 10 cm Hg exceeded considerably that to water at the same temperature of the wire, and a higher maximum of nucleate boiling was found. Solutions containing small amounts of skim milk in water showed similar high maxima. From author's summary

1617. Dimopoulos, N., I. Heat transfer to flowing water in case of high heat flow density and in case of local boiling (evaporation cooling); II. Heat transfer in a two-stroke diesel engine: influence of the surface boiling (in German), *ETH* Prom. no. 2517, 107 pp., 1955.

Heat transfer at high heat flow density was examined in a thick-walled nickel tube of 20-mm inside diam, 62-mm outer diam, 160 mm long, heated in a salt ("Hitec"—55% KNO_3 + 45% $NaNO_3$) bath by an 8kW heating coil. With local evaporation, heat transmission is no longer influenced by the velocity of the coolant but more so by its pressure and thermal characteristics (saturation temperature). Applied to the cooling of a diesel engine cylinder it is shown that the cooling is affected only slightly by the velocity or by the temperature but rather by pressure, which should be as low as possible. To keep the wall temperature low is important from the viewpoint of heat stress and cylinder wear.

W. Gumz, Germany

1618. Bellamy, J. C., Requirements for vortex thermometers, pp. 1–11. Symposium on the vortex tube as a true free air thermometer, Chicago, Ill., Armour Research Foundation, May 1955.

This was intended to be an introduction to the papers that followed. The relative merits of a vortex thermometer and a stagnation probe were compared. It was indicated that the simplicity of the vortex thermometer and associated circuitry rendered it very satisfactory for uses not requiring extremely accurate data. Paper concluded with a request for detailed investigation of the non-adiabatic processes, characteristic of vortex probes, so as to provide more firm ground upon which to accurately evaluate the merits of vortex thermometry.

After presentation of the subsequent papers, an appendix was added by the author, because it was felt that none of the papers shed any light on the physical or mathematical interpretation of the action in the tube. The appendix considered the physical factors affecting the vortex tube operation and represented work completed 5 years prior to the symposium.

Reviewer agrees with author that his paper, as well as the remainder of the symposium, fell far short of answering the fundamental problems of interest. R. J. Mindak, USA

1619. Pengelley, C. D., Thermal phenomena in a vortex, pp. 12–24. Symposium on the vortex tube as a true free air thermometer, Chicago, Ill., Armour Research Foundation, May 1955.

This review is based on research performed for the purpose of determining the commercial feasibility of using the Hilsch tube in place of the conventional expansion turbine to obtain the significant temperature drop while expanding a gas from high to low pressure. The maximum, minimum, and stagnation temperature of incoming air for one set of conditions was given for a test on a 1/2-in. diam tube. Velocity profiles, stagnation pressure profiles, as well as inlet and outlet temperatures and pressures were also given for tests run on a 5-in. Hilsch tube.

Most of the discussion concerned the mechanism of the action in the Hilsch tube. The discussion was mainly phenomenonological in nature. It was proposed that the action in the tube consists of

a central core having centrifuge flow with no radial flow but with viscosity. The central core rotates essentially as a rigid body. Surrounding the core is a transition section over an undetermined radius in which there is an undetermined flow. In the outer annulus of the Hilsch tube the flow is that of a conventional vortex from the circumference in to some critical radius.

Although the author presented some plausible arguments describing the action, he did not carry his study far enough to be of any great material value. The paper fell far short of its goal, but it should be pointed out that the author is not to blame. Lack of research funds prevented him from carrying the study to completion. R. J. Mindak, USA

1620. Eckert, E. R. G., and Hartnett, J. P., Investigation of the energy distribution in a high velocity vortex type flow, pp. 25–60. Symposium on the vortex tube as a true free air thermometer, Chicago, Ill., Armour Research Foundation, May 1955.

This paper summarizes results of a research program designed to investigate temperatures and pressures within the vortex-type flow and to interpret such measurements; the ultimate objective being to design a vortex tube in which the vortex cooling effect exactly compensates the aerodynamic heating effect over a wide range of altitude and speeds. Visual studies and physical measurements were made using a 3-in diam, 30 in. long Hilsch tube having a series of circumferentially spaced tangential inlets. The tube was of the uniflow type (the cold orifice was plugged). The 5-in. diam transparent tube having a multiplicity of controlled inlet foil shaped guide vanes was used for visual studies. Data are presented showing the radial distribution of the maximum total and static pressure, total temperature, resultant velocity, and static temperature for several axial positions. The radial variation of axial and tangential velocity at one axial position is also shown. Cross plots are presented showing the axial variation at different radii of static and total pressure, static and total temperature. In addition, data are presented showing the variation with inlet pressure at one axial position for different radii, of static pressure and static and total temperature. The results of a visual study using smoke and wool tuft are also given, as well as a brief study of the effect of the presence of pressure and temperature probes on the flow in the vortex. In the central core extending out to one-third the radius of the tube, the results were scattered or/and very erratic and gave indication of being highly turbulent. Measurements in the outer regions of the tube near the tube walls were more consistent and more readily reproducible.

From these studies it seems evident that the flow in the uniflow tube is somewhat complex in that the central core fluid and the fluid in the outer annulus near the wall have an axial direction toward the hot exit of the uniflow tube. In an annular region between the core and the outer annulus, the axial flow seems to be in the opposite direction toward the blind end of the tube, which would indicate that some of the fluid remains in the tube for a considerable time period. The radial component of the velocity through the tube was presumed negligible based on visual observations of the wool-tuft studies. A large axial velocity component exists in an annulus in the proximity to the tube wall. In the main body of the fluid, however, the axial velocity is rather small. At about one-third the tube radius the axial velocity is actually reversed.

More data of the type presented in this paper are needed to give a clearer picture of the phenomenonological behavior in the vortex tube. The complete mathematical treatment of the vortex problem would seem to be impossible without a prior phenomenonological study. From the data presented here it would seem that Dr. Pengelley's [see preceding review] model of the vortex action is partially correct. Both this paper and Dr. Pengelley's have hardly scratched the surface in explaining the vortex action. However, these two papers were the only ones that attempted to study the fundamental behavior in the tube. The subsequent papers concerned primarily the application of the vortex principle and do not shed much light on understanding the behavior.

It is interesting to note that most of the findings in this paper are in good agreement with recent work of Schiebeler in Germany, and Albright and Alexander in this country. [W. Schiebeler, Publication from the Max Planck Institute for Fluid Mechanics No. 12 Gottingen, 1955 (in German); Albright, L. F., Alexander, L. G., *Jet Propulsion* p. 867, Oct. 1956.] R. J. Mindak, USA

1621. Andersson, R., Heat requirement and heat consumption in artificial wood drying with special regard to heat regeneration in continuous drying (in German), *Sven. TräforskInst. Medd.* 72-B, 8 pp., 1955.

1622. Corder, S. E., Morris, C. O., and Atherton, G. H., Suspension drying of sawdust, ASME Spring Meet., Portland, Ore., Mar. 1956. Pap. 56-S-18, 5 pp. + 18 figs.

An experimental suspension-drying system for sawdust was tested at the Oregon Forest Products Laboratory. The effects of air rate, sawdust rate, initial gas temperature, initial sawdust moisture, and sawdust-particle size were investigated. Results of these tests will prove useful in the design of suspension-drying systems for small wood particles such as sawdust.

From authors' summary

1623. Furber, B. N., Some heat and mass transfer experiments on humid air in turbulent flow over a plane containing an isolated cooled region, *Instn. mech. Engrs. Proc.* **168**, 35, 13 pp., 1954.

The influence on both heat transfer and mass transfer of a non-transferring section upstream of the transferring region has been shown to be very important. For an extreme case the mean coefficient was 86% greater than the corresponding mean coefficient for transfer from the leading edge of the plane. This is not a maximum difference, and higher values are likely for L_{st}/L_{tot} values greater than 0.96.

A theoretical correlation for L_{st}/L_{tot}, using a method due to Owen (1951), has been attempted. Considering the assumptions made in the analysis, of which perhaps the most important is the assumption of a turbulent boundary layer starting at the leading edge, the correlation was found to be satisfactory over the range tested. ($Re = 10^4$ to 10^6 and $L_{st}/L_{tot} = 0.12$ to 0.96.) Empirical correlations due to Jakob and Dow (1946) and Maisel and Sherwood (1950) are compared with the author's suggested correlation. These do not indicate a Reynolds number effect but otherwise agree satisfacotrily over their experimental range.

When the experimental results are corrected to $L_{st} = 0$, they can best be expressed by the following relations

heat transfer

$$bL/k = 0.0621\,Re^{0.746} \doteq 0.033\,Re^{0.80}$$

mass transfer

$$b_dL/D = 0.0722\,Re^{0.735} \doteq 0.034\,Re^{0.80}$$

The results are seen to agree well with the Lewis relation which can be stated, by assuming the Prandtl and Schmidt numbers equal, in the form

$$\frac{bL}{k} = \frac{b_dL}{D}$$

When plotted in the Colburn j form

heat transfer

$$j = 0.070\,Re^{-0.254} \doteq 0.037\,Re^{-0.20}$$

mass transfer

$$j = 0.070\,Re^{-0.255} \doteq 0.037\,Re^{-0.20}$$

and Colburn's recommended correlation is

$$j = 0.0355\,Re^{-0.20}$$

Other experimental work agrees to within ±40%.

Agreement with calculated values is as follows

von Kármán $\quad Nu = 0.040\,Re^{0.781} \doteq 0.032\,Re^{0.80}$

Latzko $\quad Nu = 0.0253\,Re^{0.80}$

But the analysis of Latzko is based on a temperature distribution of the simple form

$$\frac{t - t_0}{t_1 - t_0} = \left(\frac{y}{\delta}\right)^{1/7}$$

This cannot be true near the wall.

The measured velocity profiles for the plane with a round nose were found to agree with

$$\frac{U}{U_1} = \left(\frac{y}{\delta}\right)^{1/7}$$

when δ was the theoretical value, except for some tests in the Reynolds number range $< 2 \times 10^5$. Transition flow would be expected in this region but no critical value of Reynolds number was noted.

The influence on heat transfer and mass transfer of fitting a square nose to the plane was small compared with the influence on velocity profile. From author's summary

Combustion

(See also Revs. 1443, 1591)

1624. Anagnostou, E., Brokaw, R. S., and Butler, J. N., Effect of concentration on ignition delays for various fuel-oxygen mixtures at elevated temperatures, *NACA TN* 3887, 34 pp., Dec. 1956.

This is primarily a report of new data obtained using a flow system, with ignition being detected by pressure increase. Fuels tested were propane, ethane, isobutane, n-butane, and hydrogen. Variations with temperature, flow rate, fuel concentration, and oxygen concentration were studied.

As usual, the actual values for ignition delay were found to be dependent on the experimental method, but trends agree for different methods. Delays were inversely proportional to fuel concentration, to a power ranging from 0.6 to 1.7 depending upon the fuel and sometimes on temperature. Delays were also inversely proportional to oxygen concentration, the dependence being less than for the fuel and being greatest when oxygen concentrations were low.

An interesting attempt was made to determine the importance of pre-ignition cracking of the hydrocarbons, but the results were inconclusive. R. C. Anderson, USA

1625. O'Neal, C., Jr., Effect of pressure on the spontaneous ignition temperature of liquid fuels, *NACA TN* 3829, 21 pp., Oct. 1956.

Spontaneous ignition temperatures from 1 to 9 atmospheres were measured in air for *n*-heptane (straight-chain paraffin), isooctane (branched-chain paraffin), benzene (aromatic), and JP-4 and JP-5 fuels. A 125-cc Erlenmeyer flask was employed as the ignition chamber, and fuel was injected in a solid stream (no spray) into the flask enclosed in a bomb. Fuel charges were varied to obtain the lowest temperature at which ignition occurs. Time lags before ignition were measured at each pressure for all fuels.

All fuels that were tested showed a decrease in the spontaneous ignition temperature as the pressure was raised; the rate of decrease was greatest in the range of 1 to 3 atmospheres. The total decrease of the spontaneous ignition temperature over the pressure range considered was 276 C for benzene, 236 C for isooctane, 60 C for *n*-heptane and JP-4 fuel, and 41 C for JP-5 fuel.

The difference in the spontaneous ignition temperature of two fuels at 1 atmosphere becomes less at a higher pressure. For example, JP-4 and JP-5 fuels differ by 25 C at 1 atmosphere and by 8 C at 9 atmospheres.

Two jet fuels that were specified as JP-4 showed a constant difference of about 20 C in the spontaneous ignition temperature over the experimental pressure range. By percolation of the fuel samples through silica gel, the spontaneous ignition temperature of the fuel with the higher value was reduced by approximately 10 to 12 C.

From a limited number of ignition lag experiments with *n*-heptane, the lag was found to decrease with increasing pressure. Experiments were performed with three fuel charges, and ignition lags were measured at three pressures with each charge. Semi-logarithmic plots of the time lag against the reciprocal of the absolute temperature gave lines showing some curvature. Activation energies were calculated from the slope of these curves, and were found essentially invariant with variation of fuel charge and pressure. The average activation energy was approximately 21,000 calories per mole. From author's summary

1626. Potter, A. E., Jr., and Berlad, A. L., A relation between burning velocity and quenching distance, *NACA TN* 3882, 19 pp., Nov. 1956.

Simple thermal theories show burning velocity to be proportional to the square root of the product of thermal diffusivity and reaction rate. The Einstein diffusion equation suggests that quenching distance is proportional to the square root of the product of thermal diffusivity and a characteristic time; this time may be represented by the inverse of the reaction rate in the not quite quenched flame. It follows from the above that the product of burning velocity and quenching distance is proportional to thermal diffusivity, and that the ratio of burning velocity to quenching distance is proportional to reaction rate. These concepts, together with some largely empirical refinements, are tested against experimental data and found to yield reasonable results in most cases. Hydrocarbon-nitric oxide flames are anomalous. R. Friedman, USA

1627. Neduzhy, I. A., On the theory of the calculation of atmospheric burners (in Russian), Sb. Transport i ispolzovanie prirodnogo gaza, Kiev, Gostekhizdat. 178–199, 1953; Rev. no. 143, *Ref. Zh. Mekh.* 1956.

On the basis of work done on the investigation of turbulent flow and ejectors, author makes certain statements which are basically of a qualitative nature, of the choice of dimensions of the mixing chamber and burner head, and also of the working conditions of atmospheric burners; in which mixing of the burning gas and air occurs partly in the burner (primary air) and partly in the combustion process (secondary air). L. A. Klyachko, USSR

Courtesy of Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

1628. Potter, A. E., Jr., and Berlad, A. L., A thermal equation for flame quenching, *NACA Rep.* 1264, 7 pp., 1956.

See AMR **8**, Rev. 3929.

1629. Bell, K. M., and Tipper, C. F. H., The slow combustion of methyl alcohol. A general investigation, *Proc. roy. Soc. Lond.* (*A*) **238**, 1213, 256–268, Dec. 1956.

The slow combustion of methyl alcohol in an uncoated Pyrex vessel has been investigated at temperatures between 430 and 470 C, and at pressures below atmospheric. The kinetics of the reaction were studied by means of pressure-time curves. There was no period of negligible pressure change, the reaction accelerating from a small to the maximum rate. Both the initial and the maximum rate were sensitive to surface conditions. The maximum rate was increased by the addition of "inert" gas, and varied approximately as the square of the alcohol pressure and was independent of the pressure of oxygen. The over-all activation energy was 53 and 61 kcal in an old and a new vessel, respectively.

The products of the reaction were carbon monoxide and water with small amounts of formaldehyde, hydrogen peroxide, carbon dioxide, and hydrogen. The pressure change was found to be a true measure of the extent of reaction. The pressure of formaldehyde rose to a maximum at the time of the maximum rate, and this maximum pressure was independent of oxygen pressure and proportional to the pressure of alcohol. The effect of water, carbon monoxide, formaldehyde, and aniline and *o*-toluidine, added initially, was investigated.

It is suggested that the oxidation involves a chain mechanism with delayed branching, the primary initiation reaction being rapid compared to those in the slow combustions of many other fuels. A reaction scheme, which explains the kinetic and analytical results, is proposed, HO_2 radicals propagating the chains and terminating them by reaction on the walls.

From authors' summary

1630. Norrish, R. G. W., and Taylor, G. W., Cool flames in the combustion of toluene and ethylbenzene, *Proc. roy. Soc. Lond.* (*A*) 238, 1213, 143–153, Dec. 1956.

The oxidation of toluene and ethylbenzene has been studied in a static system using a spherical reaction vessel (700 ml) over the temperature range 300 to 500 C, and at total pressures up to 600 mm. Cool flames were observed in the oxidation of both hydrocarbons, but only the reaction of ethylbenzene gave rise to a "blue" flame at higher temperatures. With neither hydrocarbon did periodicity in light intensity, or pressure pulses, occur. The ignition diagrams for 4-to-1 fuel + oxygen mixtures have been mapped out. With ethylbenzene, the cool flame was maintained in a flow system, its spectrum was photographed and shown to be similar to that of fluorescent formaldehyde. The products of the reaction contained acetophenone, benzaldehyde and benzoic acid, phenol, quinol, hydrogen peroxide, and methoxyhydroperoxide.

The results have been compared with corresponding data for the oxidation of paraffin hydrocarbons, and it is concluded that, with both aromatic compounds, the processes allowing the possibility of cool-flame formation are themselves secondary in nature.

From authors' summary

1631. Chambre, P. L., and Acrivos, A., On chemical surface reactions in laminar boundary layer flows, *J. appl. Phys.* **27,** 11, 1322–1328, Nov. 1956.

The rate of an isothermal chemical reaction on a catalytic surface is analyzed. Fully developed boundary-layer flow is treated in place of the usual assumption of a mean constant flow velocity. The case of flow parallel to a very thin flat plate is treated in detail. Comparison is made with simplified theories for a first-order reaction. Numerical agreement is reasonably close, although the simplified equation is not entirely correct.

The theory presented can be generalized to more complicated reactions and flows. Its principal aim is to calculate actual surface concentration without sacrificing hydrodynamic features or introducing unnecessary assumptions about the reaction mechanism. The method is related to an analysis of convective heat transfer from a nonisothermal surface.

Reviewer believes simplified equations will still be required for complex chemical reactions because of the difficulty of obtaining a solution to the more exact equations.

M. Gerstein, USA

1632. Blackshear, P. L., Jr., Growth of disturbances in a flame-generated shear region, *NACA TN* 3830, 148 pp., Nov. 1956.

Theoretical part of paper is a stability analysis of velocity profiles with "corners", arising when a baffle stabilizes flame in premixed combustible gas in parallel duct. Flow is shown to be neutrally stable to symmetric disturbances and unstable to antisymmetric ones. Experimental part consists of measurements on flames disturbed by sonic wave generator. Qualitative agreement is reported. Most disturbing sound frequency was just twice that predicted theoretically. D. B. Spalding, England

1633. Marshak, Yu. L., Study of the furnace designed by the All-Union Heat-Engineering Institute with high slag collection when fired with Kizel coal (in Russian), *Teploenergetika* **3,** 2, 12–20, Feb. 1956.

1634. Watts, G. A., and Sage, W. L., Multifuel-firing of cyclone furnaces, *Mech. Engng., N. Y.* **78,** 9, 823–827, Sept. 1956.

The cyclone furnace was developed to burn low-grade bituminous coals which normally have a high content of low fusing-temperature ash. The application of the cyclone has since been broadened to include a wide range of coals; also the firing of gas or oil, either in combination with coal or as stand-by or substitute fuels. Recent developments have shown that the cyclone is also capable of burning waste or by-product fuels, such as wood, chars, and cokes. This paper reviews the laboratory and field experience on the suitability of the cyclone furnace for these various applications. From authors' summary

1635. Mordell, D. L., and Foster-Pegg, R. W., Tests of an experimental coal burning turbine, ASME Ann. Meet., Chicago, Ill., Nov. 13–18. Pap. 55–A–158, 18 pp. + 17 figs., 1955.

1636. Gluckstein, M. E., Morrison, R. B., and Nehemias, J. V., The use of nuclear radiation in combustion research, *Jet Propulsion* **26,** 8, 637–643, Aug. 1956.

The possibility of altering combustion reactions by means of nuclear radiation imposes experimental techniques upon the combustion researcher with which he is unfamiliar. Techniques for handling alpha and beta emitters with respect to laboratory burners are outlined. Nuclear radiation increases the population of high energy species such as ions in the system. Its effectiveness in increasing the over-all reaction depends upon the particular chemical kinetics involved. Then the influence on combustion phenomena is dependent upon the role that chemistry plays in the process. H. F. Calcote, USA

Ballistics, Detonics (Explosions)

(See Rev. 1603)

Soil Mechanics, Seepage

(See also Revs. 1417, 1454, 1643)

1637. Hubbert, M. K., Darcy's law and the field equations of the flow of underground fluids, *J. Petr. Technol.* **8,** 10, 222–239, Oct. 1956.

A statement is made in the October, 1956, issue of the *Journal of Petroleum Technology* that the above paper was prepared for presentation before the Darcy Centennial Hydrology Symposium of the International Association of Hydrology held in Dijon, France, Sept. 20-26, 1956 and for dual publication as part of the Dijon Symposium and in the Darcy Centennial Issue of the *Journal of Petroleum Technology*.

Author starts by reviewing a series of experiments described by Henry Darcy in 1856 that deal with the flow of water through filter sands. Considerable emphasis is given to the relationship "$q = -K(h_2-h_1)/l$ in which q is the volume of water crossing unit area in unit time, l is the thickness of the sand, h_1 and h_2 the heights above a reference level of the water in manometers terminated above and below the sand, respectively, and K is a factor of proportionality." The main point of this paper seems to be that in recent years the above empirically derived equation has been generalized and given the name of Darcy's law and, in turn, has been misused by many other authors. The author of the above-titled paper makes the stern accusation that many investigators either are unaware of or are indifferent to the fact that the manometer head symbol in the above equation is composed of a pressure term and a body-force term. Specifically, author appears to believe that the gravity-force term has been neglected in many cases where it should have been considered. He also presents a direct derivation of Darcy's law from the Navier-Stokes equation and then redevelops the field equations for flow of fluids through porous media. The direct derivation based on the Navier-Stokes equation is not clear to reviewer. J. Aronofsky, USA

1638. Shekhter, O. Ya., Experimental investigations of the vibro-compression properties of sands (in Russian), *Trudi n-i. Inst., Osnvanii. i. fundamentov.* no. 22, 88–95, 1953. Rev. no. 429, *Ref. Zh. Mekh.* 1956.

Results are given of the investigation of the process of compacting dry, moist, and water-saturated sands of various granulometric composition by the combined action of vibrations and normal pressure. The tests were performed in laboratory conditions by means of a spring compression machine.

Courtesy of Referativnyi Zhurnal O. A. Savinov, USSR
Translation, courtesy Ministry of Supply, England

1639. Izbash, Yu. V., The problem of vibro-sinking of piles, tongue and groove planking, and pipes (in Russian), *Sb. Trad. Poltavskago. Inst. inzh. s-kh. str.-va.* no. 2, 174–191, 1954; Rev. no. 426, *Ref. Zh. Mekh.* 1956.

The results are given of laboratory tests made with the purpose of explaining the factors influencing the rate of sinking of vibrating piles of various designs in small-grain sands with a moisture content of ~ 6%, in trough of 160 × 60 cm. By tests with conical piles of 2.2-cm diam and a length of 125 cm with a load of 1.5 kg/cm², it was shown that, with a variation of the angle with an apex between the limits 180 – 20°, the maximum rate of sinking corresponds to the apex angle of 30 – 55°, but at other angles, it is abruptly reduced.

Variation in the perimeters of the piles (the ratio of the limiting perimeters amounted to 1:2.6) with one and the same area, had no practical effect on the rate of sinking. With an increase of the load from 1.5 to 3.25 kg/cm² on an annular pile of a diameter of 2.2 cm, the rate of sinking abruptly diminished. The rate of sinking also depends on the density of the sand, rapidly decreasing when passing from a porous state to a mean density and slowly decreasing with its further compacting. With increase of the area of the pile which is sunk, with the same weight of equipment and other conditions being equal, the rate of sinking decreased. It was found by tests that there is an optimum speed for the vibrator corresponding to the maximum rate of sinking of the pile, and the relationship of the power required by the motor to the rpm of the vibrator shaft was also determined. A vibrator speed for vibro-sinking in sand, soil of 2,600 to 3,800 rpm is recommended. It is pointed out that the total resistance to the penetration of the vibrating body in the soil is the sum of the frictional resistance according to the lateral area of the pile, and the resistance of the soil which is subjected to penetration by the tip of the pile. It is noted that the coefficient of friction of the vibrating pile against the soil is less than that of a pile displaced by a static force. M. V. Malyshev, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1640. Kyvellos, M. G., Study of shearing resistance of compacted and unsaturated soils (in French), *Ann. Inst. tech. Bât. Trav. publics* **9**, 101, 385–411, May 1956.

Author has investigated the shearing resistance of a slightly plastic ($w_L = 0.295$, $w_p = 0.210$) sandy silt, whose grain-size distribution falls almost entirely in the range 0.002 ÷ 0.2 mm. Samples were prepared by adopting a special technique to eliminate the error due to contact of adjacent layers.

After compaction, the samples were partially dried and brought to different water contents; on these samples a series of mechanical tests (unconfined compression, torsion shear, triaxial compression) were performed. From the results of the tests, plotted as a function of saturation degree reached by samples after the drying process, author draws the conclusion that the angle of shearing resistance and the cohesion are functions of the saturation degree only.

The study might have been of wider technical interest if performed on as-molded samples. However, a notation would have been desirable on the technique adopted in triaxial tests (S, Q_c, or Q), which is known to influence appreciably the results of the tests, even in the case of partially saturated soils.

R. Jappelli, Italy

1641. Rostovikov, V. I., Influence of the rate of increase of stress on the deformability of cohesive soil (in Russian), *Trudi Kieosk. gidromelion. Inst.* no. 4, 195–207, 1954; Rev. no. 427, *Ref. Zh. Mekh.* 1956.

Experiments are described which consist of loading and unloading a heavy dusty clay with an upper plasticity limit of 35%, in a lever press, by means of compressing a flat punch into the surface of compacted soil. The uniform increase and decrease of the load was effected by filling a vessel with water, this vessel being hung from the end of the lever (at rates of stress increase of 0.05 to 5 kg/cm² per minute and by the use of a special appliance (at high rates) up to 2200 kg/cm² per minute). The deformation is determined by direct measurement with indicators. Elastic and plastic deformation were considered separately. Graphs are given, the influence of the rate of increase of stress on the deformation for various moistures of the soil and stresses. An empirical formula is given which connects the deformation δ and the rate of increase of stress v

$$\delta = l[k/(b - a/v)]$$

where a, b and k are empirical coefficients.

Courtesy of Referativnyi Zhurnal A. M. Kholodov, USSR
Translation, courtesy Ministry of Supply, England

1642. Fritsch, V., Geoelectrical determination of the coefficient of permeability K (in German), *Wasserwirtschaft* **46**, 12, 305–310, Sept. 1956.

Field measurements of electric resistance of soil ρ_g and of pore water ρ_w in bore holes have been carried out over a large area; also, the porosity δ_w, the effective grain size d_w, the soil resistance ρ_g and the pore water resistance ρ_w of the extracted soil samples have been determined in laboratory. Author compares the field and laboratory results for ρ_g and ρ_w with each other and the obtained $d_w - \delta_w$ and $\rho_g = f(\rho_w, \rho_f, \delta_w)$ relationships with the theoretical formulas, ρ_f being the electric resistance of the solid skeleton. Although the scattering of the results is considerable, author believes that it is due to the heterogeneity of soils and that the theoretical relationships can be applied. Therefore, the Terzaghi formula $K = f(\delta_w, d_w)$ can be expressed by $K = f(\rho_g)$. The resulting values agree satisfactorily with some results of pumping tests. L. Suklje, Yugoslavia

Micromeritics

(See also Revs. 1466, 1488, 1637, 1642)

1643. Matthews, C. S., and Lefkovits, H. C., Gravity drainage performance of depletion-type reservoirs in the stripper stage, *J. Petr. Technol.* **8**, 12, 265–274, Dec. 1956.

Performance of depletion-type reservoirs at the stage in which the gas is at such low pressure that gravity is essentially the sole driving force has been investigated theoretically and by use of scaled models. A simple theory is developed which completely explains the scaled model experiments. It also agrees with some field data. When the ratio of production rates to be considered is less than 25, the theory predicts that the production rate q as a function of time t for homogeneous reservoirs in which there is a free surface will be $q = q_0/(1 + \gamma t)^2$. The effects of permeability, viscosity, bed thickness, and well-bore radius were measured.

From authors' summary by C. F. Bonilla, USA

1644. Chernov, A. P., Resistance coefficients of solid particles in gaseous suspension (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 11, 135–138, Nov. 1955.

1645. Frumkin, A. L., Problems in the theory of floating dust

removal from mine air by means of sprinkling (in Russian), *Izv. Akad. Nauk SSSR Otd. Tekh. Nauk* no. 11, 129–134, Nov. 1955.

Geophysics, Meteorology, Oceanography

(See also Revs. 1344, 1355, 1551, 1554)

1646. Manabe, D., Types of storm and analytical considerations on the ocean waves around Japan (in Japanese), *J. Zosen Kiokai* no. 99, 87–92, 1956.

From Sverdrup-Munk's theory, together with some experimental knowledge, the several relations among the characteristic quantities regarding ocean waves are derived; namely, minimum value of wave age is found to be almost constant, i.e. 0.4, and wave length, period, and maximum height are given by $0.1\ u_m^2$, $0.26\ u_m$, and $0.01\ u_m^2$, respectively, where u_m is the maximum wind speed within a storm and the units are all in M. K. S. These results are also verified by comparison with the observed data, and a fairly good accordance is obtained. K. Miyakoda, Japan

1647. Pyshkin, B. A., The study of the dynamics of the shores of Lake Lenin (in Russian), *Trudi Inst. Okeanologii Akad. Nauk* 10, 85–91, 1954. Rev. no. 205, *Ref. Zh. Mekh.* 1956.

Certain results are given of the investigation of the dynamics of the shores of Lake Lenin (reservoir of the Dnepr. hydroelectric station) from data obtained by observation. The height of the waves at various sections of the dam is 2, 1.6, and 1.2m and the maximum length of the waves 32m. The maximum velocity of the wind currents, calculated from the formula of P. K. Bozhich $v = Aw$ (w = wind velocity, $A \sim 01015$ to 0.025) amounts to 0.3 to 0.5 m/sec. The mean erosion of the shore from 1935 to 1946, according to observations at three sections, amounts to 200 m^3/m of length of shore. The width of the strip is from 10 to 25 to 50 to 100 m. Putting the mean rate of destruction at half the maximum, he makes the complete time for reformation of the shore 50 to 75 years. The work of the waves N, determining the motion of the deposits, is calculated according to the formula $N = kh^3t$ (h height of wave, t duration of action). In order to study the relative picture of the removal of the deposits it is not necessary to know k. On the basis of the wave refraction theory of V. V. Shulakin for reservoir conditions, the following formula is suggested:

$$\cos \delta_{shore} / \cos \delta_{sea} = \tfrac{1}{4}(3 + b/H_{sea})$$

in which δ_{shore} and δ_{sea} are the angles between the line of the shore and the direction of waves propagated at the shore and in the open sea, respectively, and H the sea depth. The quantitative calculation of the erosion, in the author's opinion, enables the future outline of the shore line to be forecast.

Courtesy of Referativnyi Zhurnal P. S. Lineikin, USSR
Translation, courtesy Ministry of Supply, England

1648. Bowden, K. F., and Fairbairn, L. A., Measurements of turbulent fluctuations and Reynolds stresses in a tidal current, *Proc. roy. Soc. Lond.* (*A*) **237,** 1210, 422–438, Nov. 1956.

Observations have been made of u and w, the horizontal and vertical components of turbulent velocity, in a tidal current, at heights of 50 to 175 cm above the bottom. The measuring instrument was an electromagnetic flowmeter, in which the magnetic field was produced by a c at 50 cps and the p d induced in the flowing water was measured by two pairs of electrodes. The measuring head of the instrument was 10 cm in diameter, and two such heads were mounted on a tripod which was laid on the sea bed. The observations were made off Red Wharf Bay, Anglesey, in depths of 12 to 22 m, on a fairly flat bottom consisting mainly of firm sand. For mean currents, U, in the range 25 to 50 cm/s, the rms values of u were of the order of 10% of U, while those of w were about 6% of U. On a number of records, u and w were recorded simultaneously, and from these the Reynolds stress $-\rho[uw]$ was evaluated. At 75 cm above the bottom the values of stress were from 2 to 4 dyn/cm², the corresponding coefficient of correlation between u and w averaging −0.4. Autocorrelation curves and spectrum functions computed from these records showed that u contained considerably more energy in the fluctuations of longer period than w did. Other records were of traces of u or of w at two different heights and showed the smaller vertical scale of w compared with that of u. In the case of u, the vertical scale appears to be only about one third of the scale in the direction of the mean flow.

From authors' summary by H. J. Schoemaker, Holland

1649. Aubert, E. J., A multi-level baroclinic model applicable to numerical prediction, *J. Meteor.* **13,** 2, 207–211, Apr. 1956.

1650. Thompson, P. D., and Gates, W. L., A test of numerical prediction methods based on the barotropic and two-parameter baroclinic models, *J. Meteor.* **13,** 2, 127–141, Apr. 1956.

Lubrication; Bearings; Wear

1651. Ausman, J. S., The fluid dynamic theory of gas-lubricated bearings, ASME-ASLE Lubrication Conf., Atlantic City, N. J., Oct. 1956. Pap. 56-LUB-6, 10 pp.

Using the Navier-Stokes equation for fluid motion and the customary inertia, velocity, and viscosity assumptions, author derives the differential pressure distribution equation for gas-lubricated bearings. It is a nonlinear partial differential equation in the pressure p, involving an isentropic change of state in a perfect gas. The equation is adapted to an infinite width, autolubricated, gas-journal bearing and solved by means of a series expansion. It is shown, by comparison to solutions of the better-known Harrison equation, that use of only the first three terms of the series yields pressure and load values of sufficient accuracy. Thus the derived equation along with the perturbation solution provides satisfactory results at a saving of time and effort.

J. P. Vidosic, USA

1652. Du Bois, G. B., Ocvirk, F. W., and Wehe, R. L., Properties of misaligned journal bearings, ASME-ASLE Lubrication Conf., Atlantic City, N. J., Oct. 1956. Pap. 56-LUB-7, 10 pp.

Experimental data on misaligned journal bearings under hydrodynamic conditions of lubrication are presented. Curves in dimensionless form give bearing attitude as a function of usual variables and misaligning couples. Examples of design problems are given. From authors' summary by W. J. Anderson, USA

1653. Nemeth, Z. N., and Anderson, W. J., Temperature limitations of petroleum, synthetic, and other lubricants in rolling-contact bearings, *SAE Trans.* **63,** 557–566, 1955.

Studies of 20-mm-bore tool-steel ball bearings operated at 2500 rpm and lubricated with graphite, or molybdenum disulfide-air mist, or one of several liquids (both petroleum and synthetic types) are reported in this paper.

Effective lubrication at 1000 F with graphite, at 850 F with molybdenum disulfide, and at 700 F with a synthetic diester was obtained.

A second investigation of the effectiveness of molybdenum disulfide-air mist as a lubricant for high-speed roller bearings is also reported here. Successful operation of a 75-mm-bore cageless roller bearing at a DN of 0.975×10^6 (13,000 rpm) with no external heat added was obtained. From authors' summary

Marine Engineering Problems

(See also Revs. 1345, 1347, 1443, 1480, 1530)

1654. Wendel, K., Hydrodynamic masses and hydrodynamic

moments of inertia, *David W. Taylor Mod. Basin Transl.* 260, 81 pp., July 1956. (Translated by E. N. Labouvie and A. Borden)

Author uses potential theory to define terms "hydrodynamic mass," m'', and "hydrodynamic moment of inertia," J'', in statements of pressure forces or moments resulting from accelerated translation or rotation of a body in an ideal fluid. "Hydrodynamic mass" (*alias* "added mass"), in combination with the mass of the body gives "apparent mass," which, multiplied by acceleration, represents the force needed to accelerate the body through the fluid. "Hydrodynamic moment of inertia" is rotational equivalent of "hydrodynamic mass." Author examines two-dimensional problem of potential of field of flow in the plane of accelerating rectilinear cross sections with and without bilge-keels in an infinite fluid, using approaches such as direct solution of boundary-value problem and conformal representation. Value of m'' is determined from expression of kinetic energy of flow in terms of potential; J'' from kinetic energy of rotation. Excellent confirmation of available experimental results derives from the analysis. Author extends this to sections in a free surface and finite fluid depth. Results have immediate bearing on theory of ship perturbations. Dependence of m'' and J'' on oscillation frequency is indicated but considered negligible for ship vibrations; low frequency effects, however, are likely to increase m''. Author concludes with valuable listing of results for different cross sections, and practical applications to ship theory of heaving, rolling, and flexural vibrations.

Reviewer considers work an outstanding example of analytic achievement, of great importance to ship designers and hydrodynamicists. B. W. Wilson, USA

1655. Voitkunsky, Ya. L., Calculation of the drag coefficients and combined moments of inertia in the rolling motion according to the results of tests of ship models (in Russian), *Tr. Leningr. Korablestroit. Inst.* no. 13, 3–11, 1954; Rev. no. 234, *Ref. Zh. Mekh.* 1956.

According to the recording of the damped oscillation of a ship model or of the ship itself, the coefficients of drag on the rolling motion, and the combined moment of inertia of the ship about the longitudinal axis, are determined with an arbitrary nonlinear relationship of the restoring moment to the angle of roll, and the quadratic relationship of the moment of drag to the velocity.

Courtesy of Referativnyi Zhurnal I. S. Riman, USSR
Translation, courtesy Ministry of Supply, England

Letters to the Editor

1656. Concerning AMR **9,** Rev. 3827 (December 1956): **Mestschorski, I. W., Problems in mechanics.**

It has been drawn to our attention that the book, the German translation of which was reviewed under the above mentioned number, has also been published by the MacMillan Company in an English translation, the eighth printing of which appeared in 1954, and the first printing in 1939. Editor

1657. Concerning AMR **9,** Rev. 1501 (May 1956): **Stuart, J. T., On the role of Reynolds stresses in stability theory.**

In view of the bias shown in the above review, may I draw attention to the facts? They are: 1. Dr. Pai (see AMR **8,** Rev. 2777) obtained a theoretical result completely out of accord with experiment, namely that two-dimensional laminar flows are stable against finite disturbances; 2. I showed that the error in his argument lay in the neglect of the effect of the Reynolds stresses on the mean motion; 3. Dr. Pai rejected my refutation of his proof and argued that my definition of stability was different from his (see *J. aero. Sci.* Mar. 1956, p. 274).

To comment on the review, I did not define stability differently from Dr. Pai; consequently, the last two sentences are irrelevant. The first sentence of the review is quite correct.

J. T. Stuart, England

1658. Concerning AMR **9,** Rev. 1079 (April 1956): **Klein, B., Certain aspects of efficient structural design.**

Apparently Dr. Williams suggests that the Rayleigh-Ritz method be used to solve optimum design problems. First let it be understood that the nonlinearity of the equations is inherent in such problems. This predicament cannot be circumvented by any analytic method. It is precisely because of the highly nonlinear nature of the equations that the application of the Rayleigh-Ritz method would be quite cumbersome indeed. In ordinary linear stress-distribution or eigenvalue problems the Rayleigh-Ritz method works nicely since the boundary conditions usually may be satisfied, approximately at least, and equations are linear. However, in optimizing problems, boundary conditions are replaced by highly nonlinear constraining functions of the unknown functions. Therefore, in general, use of the Rayleigh-Ritz method, in which a set of functions is assumed, leads to a highly complex form of the constraining equations.

On the other hand, in many practical problems concerned with the light-weight design of structures, the use of the calculus of variations with Lagrangian multipliers leads to the solution for the *form* of the unknown functions in a direct manner even though the equations are highly nonlinear. For example, the author has recently solved the problem of determining the light-weight design of a centrally loaded strut of tapered tubular cross section but with given end load and length. The constraining equations in this case specify that no local wall crippling occur at any section nor Euler type buckling (including plasticity effects and Johnson Parabola form) take place. The Ramberg-Osgood stress-strain equation was used to determine the expression for the tangent modulus as a function of stress. The solution for the tube radius distribution is very similar to that obtained by Ayers and shown in Fig. 2 of his recent paper in *Aircraft Engineering.* However, the wall thickness must be beefed up near the end region of the column with consequent weight penalty.

In conclusion, it should be realized that Lagrangian multipliers are necessary in the method in general where it is impossible to eliminate unknown quantitites from the nonlinear equations.

B. Klein, USA

1659. Concerning AMR **9,** Rev. 3879 (December 1956): **Ito, K., Studies on photoelasto-plastic mechanics.**

The author's name was given as Katsuhiko, I., rather than Ito, K.

The editors regret this error.

Books Received for Review

ARMSTRONG, W. H., Machine tools for metal cutting, New York, McGraw-Hill Book Co., Inc., 1957, ix + 347 pp. $5.00.

DEBING, L. M., edited by, Quality control for plastics engineers, New York, Reinhold Publishing Corp., 1957, iii + 142 pp. $4.95.

DONALDSON, C., and LECAIN, G. H., Tool Design, 2nd. ed., New York, McGraw-Hill Book Co., Inc., 1957, vii + 557 pp.

JEFFREYS, H., Scientific inference, 2nd. ed., New York, Cambridge University Press, 1957, viii + 236 pp. $4.75.

LIEPMANN, H. W., and ROSHKO, A., Elements of gasdynamics, New York, John Wiley & Sons, Inc., 1957, xv + 439 pp. $11.00.

MAYHEW, Y. R., and ROGERS, G. F. C., Thermodynamic properties of fluids and other data, 2nd. ed., Oxford, Basil Blackwell, 1957, 16 pp. (paperbound)

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